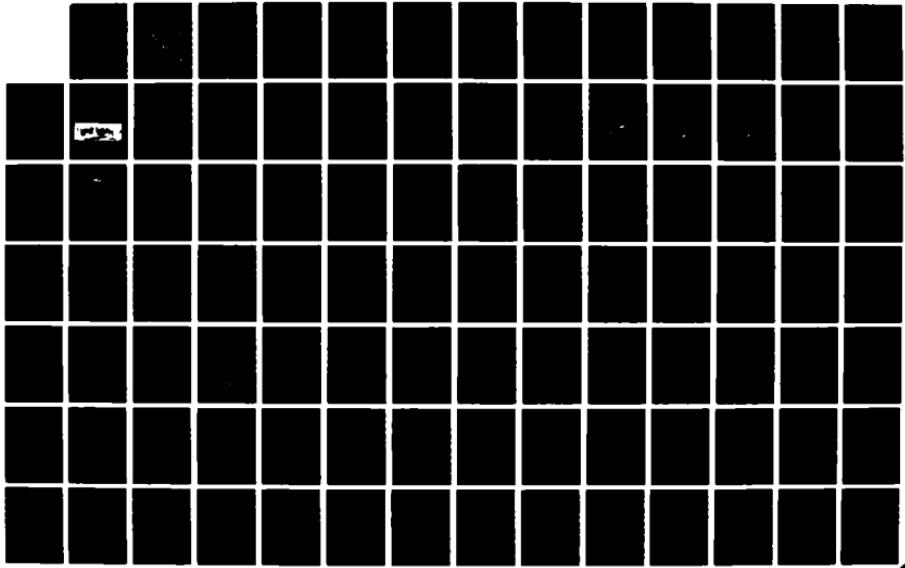
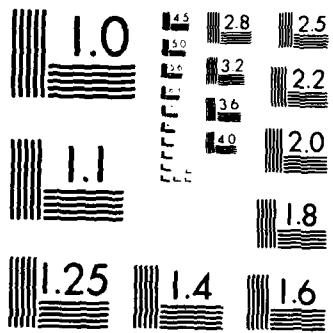


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MICROCOPY RESOLUTION TEST CHART  
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INTERNATIONAL CIVIL AVIATION ORGANIZATION  
COMMITTEE ON AVIATION ENVIRONMENTAL PROTECTION

AD-A188 540

Helicopter Noise Measurement  
Repeatability Program  
Final Report

H N M S R P



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Prepared by  
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Program Analyst, Maryalice Locke

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| <b>16. Abstract</b><br>This report summarizes the findings of the Helicopter Noise Measurement Repeatability Program (HNMRP), which was initiated by the International Civil Aviation Organization (ICAO) Committee on Aviation Environmental Protection (CAEP) Working Group II (WG II). The HNMRP was begun with the goal of further developing and refining international helicopter noise certification standards. This international effort has involved the active participation of Australia, Canada, the Federal Republic of Germany, France, Italy, Japan, the United Kingdom, and the United States.<br><br>The participating ICAO CAEP WG II nations set out to investigate the degree of variability in test results of the existent helicopter noise certification rule by conducting a multinational noise measurement flight test program using a single, widely available helicopter, the Bell 206L-1 (or the acoustically equivalent 206L-3).<br><br>The HNMRP has provided a large number of certificating authorities and industry participants the opportunity to acquire experience in helicopter noise certification and the opportunity to thoroughly test and review the requirements of Chapter 8 and Appendix 4 of ICAO Annex 16 through implementation experience. As a result of this experience, recommendations for improvements and refinements to Annex 16 were developed, and subsequently adopted as proposed amendments at the CAEP/ meeting in Montreal in June 1986. The HNMRP also provided ICAO WG II the chance to review the inherent repeatability of noise levels for a single helicopter model tested by different teams at different locations.<br><br>This report contains: a history of the HNMRP, a summary of the multi-nation comparison data, and discussion of the results of the program, including the refinements proposed for the international helicopter noise certification standard. Future analytical opportunities using HNMRP data are also discussed at the end of the report. |   | <b>13. Type of Report and Period Covered</b>   |                  |
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## GLOSSARY

|       |  |
|-------|--|
| AGL   | Above Ground Level                                 |
| ALm   | Maximum A-Weighted Sound Level                     |
| BAe   | British Aerospace                                  |
| BRC   | Best Rate of Climb                                 |
| CAA   | Civil Aviation Organization                        |
| CAEP  | Committee on Aviation Environmental Protection     |
| CAN   | Committee on Aircraft Noise                        |
| CPA   | Closest Point of Approach                          |
| Ch    | Channel  |
| dB    | Decibel  |
| dB(A) | A Weighted Sound Levels in dB                      |
| DFVLR | German Aerospace Research Establishment            |
| DGAC  | Direction General de l'Aviation Civile             |
| DOT   | United States Department of Transportation         |
| EPNL  | Effective Perceived Noise Level                    |
| EPNdB | Effective Perceived Noise Level Expressed in dB    |
| EST   | Eastern Standard Time                              |
| FPM   | Feet per Minute                                    |
| FPS   | Feet per Second                                    |
| FRG   | Federal Republic of Germany                        |
| GW    | Gross Weight                                       |
| HIGE  | Hover-In-Ground-Effect                             |
| HNMRP | Helicopter Noise Measurement Repeatability Program |
| hp    | Horsepower   |
| HV    | Height-Velocity                                    |
| Hz    | Hertz  |

|        |  |
|--------|--|
| ICAO   | International Civil Aviation Organization    |
| IEC    | International Electrotechnical Commission    |
| IRIG-B | Inter Range Instrumentation Group B          |
| kg     | Kilogram                                     |
| KHz    | Kilo-Hertz                                   |
| KIAS   | Knots Indicated Air Speed                    |
| km     | Kilometers                                   |
| km/hr  | Kilometers per Hour                          |
| kts    | Nautical Miles per Hour (Knots)              |
| LEQ    | Equivalent Sound Level                       |
| m      | Meters                                       |
| MHz    | Megahertz                                    |
| Mic    | Microphone                                   |
| mph    | Miles per Hour                               |
| OASPLM | Maximum Overall Sound Pressure Level         |
| OAT    | On-Board Outside Temperature                 |
| PAPI   | Precision Approach Path Indicator            |
| PAR    | Photo Adjusted Radar Data                    |
| PISLM  | Precision Integrating Sound Level Meters     |
| PNLTm  | Tone Corrected Maximum Perceived Noise Level |
| PSI    | Pounds per Square Inch                       |
| RAM    | Random Access Memory                         |
| RFM    | Rotorcraft Flight Manual                     |
| rh     | Relative Humidity                            |
| rpm    | Revolutions per Minute                       |
| SAE    | Society of Automotive Engineers              |
| SEL    | Sound Exposure Level                         |

|       |   |
|-------|---|
| SPL   | Sound Pressure Level  |
| SR    | Slant Range   |
| STNA  | Service Technique de la Navigation Aerienne                 |
| T/O   | Takeoff   |
| TSC   | Transportation Systems Center (US DOT)                      |
| UK    | United Kingdom  |
| US    | United States   |
| VASI  | Visual Approach Slope Indicator                             |
| Vh    | Maximum Speed in Level Flight with Maximum Continuous Power |
| VNE   | Never Exceed Speed  |
| Vr    | Reference Velocity  |
| Vt    | Test Velocity   |
| Vtoc  | Takeoff Climb Out Speed                                     |
| Vtoss | Takeoff Safety Speed  |
| Vy    | Speed for Best Rate of Climb                                |
| WG B  | Predecessor to WG II  |
| WG II | Working Group II  |
| WHL   | Westland Helicopters Limited                                |

## 1.0 INTRODUCTION

This report summarizes the activities and findings of the Helicopter Noise Measurement Repeatability Program (HNMRP), which was initiated by the International Civil Aviation Organization's (ICAO) Committee on Aviation Environmental Protection (CAEP) Working Group II in October of 1983. This enterprise was begun in the interest of further developing and refining international helicopter noise certification standards.

The HNMRP has been an international effort involving the active participation of technical and regulatory personnel from: Australia, Canada, the Federal Republic of Germany, France, Italy, Japan, the United Kingdom, and the United States.

This report has been published by the US Federal Aviation Administration (FAA). It represents the efforts of the program participants, Working Group II (WG II), the HNMRP Program Coordinator (from the FAA) and the HNMRP support staff.

Participating ICAO CAEP WG II nations set out to investigate the degree of variability in test results measured under the existent helicopter noise certification rule by conducting a multinational noise measurement flight test program which utilized a single, widely available helicopter, the Bell 206L-1 (or the acoustically equivalent Bell 206L-3).

The benefits and results of the HNMRP have been many:

First, the HNMRP provided a large number of certificating authorities and industry participants the opportunity to acquire experience in helicopter noise certification. The experience gained by each participant will be reflected in their future field testing, data reduction and analysis projects.

Secondly, the HNMRP provided WG II members the opportunity to thoroughly test and review the requirements of Chapter 8 and Appendix 4 of ICAO Annex 16 through implementation experience. As a result of this experience, recommendations for improvements and refinements were developed and formally delineated in the WG II Report to CAEP, many of which were subsequently adopted at the CAEP/1 meeting in Montreal (June 1986) as proposed amendments to Annex 16.

Thirdly, the HNMRP provided WG II the chance to review the inherent repeatability of noise levels for a single helicopter model tested by different teams at different locations.

Included in this report are the summary data for each participant, summary multi-nation comparison data, analyses, and discussion of the program results, including the refinements proposed for the international helicopter noise certification standard. Actual single event data for each participant are available in the original data source reference reports used in the construction of this document.

The HNMRP, having completed the important regulatory review portion of its agenda and having collated and summarized participant data, concluded its

program activities at the CAEP/1 meeting in Montreal in June 1986. Further analysis of results and field test experiences have been identified as proposed work items for the newly established Working Group II (1987-1990). Those and other spin-off work topics identified through the HNMRP activities and efforts have been summarized in Section 10. These adjunct study topics are also natural candidates for the new Working Group II agenda, or for the agenda of a CAEP Technical Manual committee.

The HNMRP has been a collective effort of all of the program participants. Group meetings, as well as many phone conferences, were held during the span of the program. Pictured in Figure 1.0.A are the program participants who attended the Washington, DC (US) HNMRP Evaluation Meeting held in October of 1985. From left to right, front row are: Tom Kelly (Canada), Alain Depitre (France), Ed Rickley (US), Srinivas Nagaraja (Italy), John Leverton (HAI), Susan Woolridge (US staff assistant), Mr. Kitazawa (Japan), Mr. Yoshioka (Japan), Mr. Masue (Japan), and Rowena Cross-Najafi (US staff assistant). Back row, left to right: Maryalice Locke (US), Dennis Levanduski (US staff assistant), Jean Marze (France), Vital Ferry (France), John Wesler (US), Tony Pike (UK), Dr. John Powers (US), Peter Kearsley (UK), Steve Newman (US), Ken Adams (UK), John Fennell (UK), Larry Plaster (US), Richard Tedrick (US), and Sharon Daboin-Yoshikami (US).

Figure 1.0.A



## 2.0 BACKGROUND AND HISTORY OF THE HNMRF

### 2.1 PREDECESSORS

The HNMRF evolved from two previous multinational programs sponsored by ICAO during the years 1980 through 1986.

The first program was an international "round-robin" helicopter noise analysis program (Ref 1) conducted under the auspices of the ICAO Committee on Aircraft Noise (CAN) WG B (the predecessor to WG II). The program was formulated under WG B Rapporteur Vitale Ferry, of the French Direction Generale de l'Aviation Civile (DGAC), and Program Coordinator Edward J. Rickley, of the US Department of Transportation (DOT) Transportation Systems Center (TSC). From the analysis of identical analog tapes of helicopter noise, this program provided a quantitative comparison of data reduction and analysis systems. The results showed a standard deviation (of differences) on the order 0.5 dB and a range of differences approaching 1.5 dB (3 standard deviations).

The second program was an examination, by a three nation panel, of the test to test variability of noise data from the A109-A helicopter using ICAO Annex 16 noise certification procedures (Ref 2). The A109-A study examined two separate field tests, conducted at different locations, by two different teams--but with the same model aircraft. The purpose of the program was to develop greater confidence and understanding of the application of the ICAO noise standards. The A109-A study also strived to bring to light problems, if any, regarding test repeatability, test procedures, flight procedures or any other test or data reduction factors.

The A109-A study concluded:

"The approach mode requires further examination due to the apparent variability in noise levels as seen in the A109-A case which was also observed in the case of the earlier individual campaigns carried out by the French, German and the FAA teams."

It was also recommended that further studies be conducted to acquire a better statistical knowledge of:

1. aircraft-to-aircraft variability;
2. pilot-to-pilot variability;
3. effect of wind on uneven blade loading;
4. the human dynamics of verbal flight path guidance and influence on noise data variability; and
5. the use of stability augmentation techniques verses manual control.

In addition, the report stated:

"It is important to investigate the above factors and explain such test to test variability in order to remove uncertainties and to provide the confidence required in the application of the proposed standards. Should the result of such a thorough investigation still be negative it might be necessary to consider specifying an additional degree of tolerance about the prescribed noise limits for the approach case in order to allow for 'undefinable' factors."

These conclusions and recommendations along with the "round robin" experience provided the basis for the development of the Helicopter Noise Measurement Repeatability Program.

## 2.2 WORKING GROUP II ACTIVITIES and THE HNMRP

The Rapporteur of ICAO CAEP Working Group II (1983-1986), Dr. John O. Powers, provided the following synopsis of WG II and HNMRP activities in his report to CAEP/1 (June 1986) (Ref 3). (Dr. John O. Powers retired as the Chief Scientist of the US FAA, Office of Environment and Energy in January of 1987.)

"Working Group II was established under the Committee on Aviation Environmental Protection (CAEP) to consider (along with other topics) the further development of noise standards for helicopters during the Seventh Meeting of the Committee on Aircraft Noise (CAN)(in 1983). The Working Group responded with the establishment (of a program) dealing with possible refinements of the ICAO Annex 16, Chapter 8 Helicopter Noise Standards....

"The first Working Group meeting was held on October 26-28, 1983, in Amsterdam, The Netherlands. During the meeting, Working Group members recognized and addressed the complexity and implications of conducting a helicopter noise repeatability test program. After a review of the potential difficulties, the Group decided that such a program would provide broad experience and an opportunity to evaluate the problems which could arise during the implementation of the Annex 16, Chapter 8 Helicopter Noise Standards....

"The second meeting of the Working Group was held in Boston, Massachusetts, USA, May 21-23, 1984.... The discussions... related to the helicopter program, predominantly addressed the structured repeatability test program and noise abatement operational procedures.... It was reported during the meeting that seven member nations were actively participating in the helicopter noise repeatability program. (After the meeting the number of participating nations increased to nine.) Many unique measurement techniques were discussed and early indications implied that meaningful recommendations would result from the program for presentation to CAEP/1....

"Working Group II held its third meeting in Tokyo, Japan, March 25-27, 1985.... (At that meeting the status of the HNMRP) was reviewed and specific recommendations, were either accepted or tentatively accepted dealing with takeoff flight-path definition, overflight airspeeds, maximum operational rotor speed, atmospheric absorption adjustments for takeoff, generalized source noise adjustments, and specifications for data analysis systems.... Plans were made...for a Helicopter Noise Measurement Repeatability Program (HNMRP) subgroup meeting for final analysis of test results and formulation of additional Chapter 8 recommendations...."

The last meeting of Working Group II prior to CAEP/1 was held in Ottawa, Canada, October 9-11, 1985. At this meeting a report was presented by the HNMRP Program Coordinator detailing the findings of the HNMRP Subgroup from their "Program Evaluation Meeting" (in Washington, DC, USA, October 1-4, 1985). Several additional Chapter 8 modifications proposed by the HNMRP

Subgroup were included in the Working Group II report to CAEP.

In addition to the HNMRP subgroup meeting held in Washington DC, another HNMRP evaluation meeting was held in Paris, France (April 21 to 25, 1986). This meeting was held to finalize regulatory language for the proposed amendments and refinements to the ICAO international helicopter noise certification standards.

The work of the HNMRP and Working Group II reached a significant milestone at the meeting of the first full ICAO Committee on Aviation Environmental Protection (CAEP/1) meeting, in Montreal, Canada during June of 1986. At that meeting the recommendations of Working Group II (based on Paris HNMRP agreements) were agreed to as proposed amendments to the international standard.

## 2.3 PROGRAM REFERENCE DOCUMENTATION

In this section the primary HNMRP source documentation is listed. These documents are highlighted here, in the text of the report, since they played such an important role in the program. The HNMRP was conducted in accordance with the procedures set out in these documents.

All of the source documentation material discussed here are also formally referenced in the customary manner immediately prior to the appendices.

- 1) Test Plan for the ICAO Helicopter Noise Measurement Repeatability Program, November 1983, Revised December 15, 1983. (Ref 4)
- 2) Helicopter Noise Measurement Repeatability Program Mid-Program Review Advance Phases Protocol, October 1, 1984. (Ref 5)

While general test program provisions were specified in the references cited above, the ultimate reference and focus of the program was the following document:

- 3) ICAO Annex 16 (Ref 6)

Within ICAO Annex 16, helicopter noise certification is addressed in Chapter 8, with many cross references to Appendices 2 and 4.

Other valuable reference documents were:

- 4) Bell 206L-1 Long Ranger II Flight Manual, Bell Helicopter Textron, May 18, 1978. (Ref 7)
- 5) ICAO Working Group II Background Information Paper on Agenda Item 3A, Compendium of Comments on Test Plan, May 1984 (presented by the US representative). (Ref 8)
- 6) "An Examination of Test to Test Variability for the A109-A Helicopter Using ICAO Annex 16 Noise Certification Procedures", ICAO Committee on Aircraft Noise (CAN) Working Group B, joint German, Italian, U.S. member paper, January 1983. (Ref 2)

The formal reference section, just prior to the appendices, includes a more extensive list of HNMRP references and is subdivided into four parts: General References, Participants' Submittals, HNMRP Papers, and ICAO WG II Meeting Working and Background Information Papers.

#### 2.4 REFERENCE CONDITIONS

The specific reference conditions to which data adjustments were to be made were stated in the "HNMRP Mid Program Review" document. Those reference values are repeated below:

**Helicopter reference point -**

For the HNMRP, the helicopter skid was the helicopter reference point for photo altitude determination.

**Takeoff reference profile-**

V<sub>y</sub> = 57 knots

Rate of climb = 463.3 meters per minute (1520 ft/min)

Climb angle = 15.26 degrees

Altitude over centerline center = 156.4 meters (513 ft)

CPA over centerline center = 150.9 meters (495 ft)

CPA to the sideline sites = 192 meters (630 ft)

**Approach reference profile-**

Reference approach over centerline center = 120 meters (394 ft)

Reference CPA over centerline center = 120 meters (394 ft)

Reference CPA to the sideline sites = 192 meters (630 ft)

**Level flyover reference profile-**

Reference altitude over centerline center = 150 meters  
(492 ft)

Reference CPA to the sideline sites = 212 meters (696 ft)

### 3.0 TEST PLAN

The HNMRP test plan was intended to be a guideline for the program participants. Detailed below are the flight operations and other important information included in the test plan.

Many of the participants' flight test programs also included some flight operations that were not mentioned in the test plan. These additional operations are noted in this section as well as in Section 5.

#### 3.1 TEST HELICOPTERS: BELL MODELS 206L-1 and 206L-3

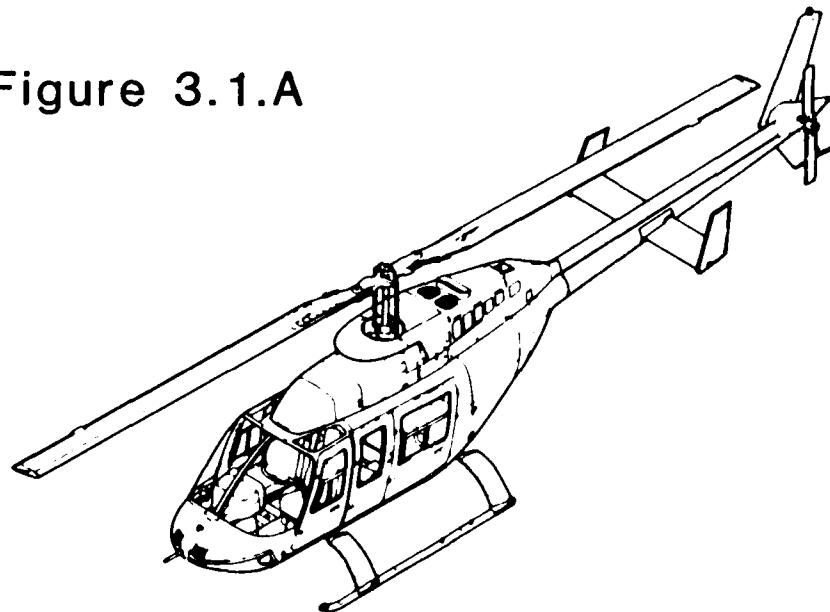
Participants in the HNMRP had the option of testing either the Bell 206L-1 (Long Ranger II) or the Bell 206L-3 (Long Ranger III) helicopter. These helicopters are considered acoustically identical, although, there are some differences in installed power and performance. The Bell 206L-1 (or 206L-3) helicopter was selected as the test vehicle because of its world wide availability. Bell 206L-1 helicopters were used in all but the Japanese flight test program, in which a 206L-3 was used.

There exist three basic models of the Bell 206 helicopter. The first version, referred to as the 206-L Long Ranger, is the earliest production model and is acoustically different (smaller tail rotor) from derivative models 206L-1 and 206L-3. Table 3.1.A is a summary of the prominent features each of the three models.

In the Japanese test program, the takeoff mass of the Bell 206L-3 was adjusted from 1882 Kg to 1796 Kg in order to achieve the same rate of climb as the Bell 206L-1. With this modification the takeoff reference altitudes of the two helicopters become, in theory, the same.

Figures 3.1.A and 3.1.B are schematic line diagrams of the Bell 206L-1 test helicopter.

Figure 3.1.A



# Table 3.1.A

## BELL MODEL 206 "FAMILY" CHARACTERISTICS

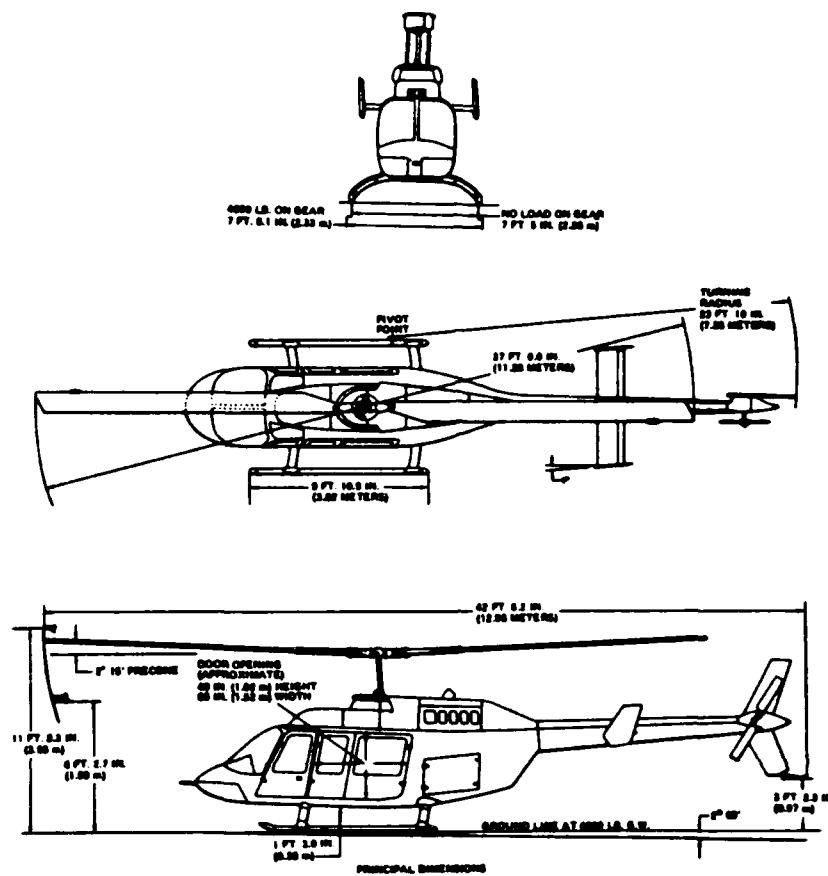
| Model                 | Bell 206-L       | Bell 206L-1      | Bell 206L-3      |
|-----------------------|------------------|------------------|------------------|
| Common Name           | Long Ranger      | Long Ranger II   | Long Ranger III  |
| Mass (Kg)             | 1814             | 1837             | 1796 ***         |
| Mass (Pounds)         | 4000             | 4050             | 3960             |
| Engine                | Allison 250-C20B | Allison 250-C28B | Allison 150-C30P |
| Installed HP          | NA               | 500              | 650              |
| Takeoff HP            | 420              | 435              | 435              |
| Transmission HP       | 428              | 435              | 435              |
| BRC (FPM)             | 1600             | 1520             | 1520             |
| BRC (FPS)             | 26.67            | 25.33            | 25.33            |
| BRC 3P. Vy (Kt)       | 52               | 57               | 57               |
| Vy (FPS)              | 87.78            | 96.22            | 96.22            |
| BRC Climb Angle       | 17.68            | 15.26            | 15.26            |
| ICAO T/O Alt.(Meters) | 179.41           | 156.46           | 156.46           |
| ICAO T/O Alt.(Feet)   | 588.61           | 513.32           | 513.32           |
| Main Rotor RPM        | 394              | 394              | 394              |
| Tail Rotor RPM        | 2550             | 2550             | 2550             |
| Main Dia.(Meters)     | 11.28            | 11.28            | 11.28            |
| Main Dia.(Feet)       | 37.01            | 37.01            | 37.01            |
| Tail Dia.(Meters)     | 1.58             | 1.65             | 1.65             |
| Tail Dia.(Feet)       | 5.17             | 5.42             | 5.42             |
| Main R-Vel (FPS)      | 763              | 763              | 763              |
| Tail R-Vel (FPS)      | 692              | 722              | 722              |
| VNE (Knots)           | 130              | 130              | 130              |
| VNE (MPH)             | 150              | 150              | 150              |
| VNE (Km/Hr)           | 241              | 241              | 241              |

NOTE: VNE = VH; (.45 VNE) + 65 = 123 knots; and (.9 VNE) = 117 knots.  
(.9 VNE) = 117 knots is the value specified as the reference speed for  
the HNMRP level flyover test.

\*\*\* For test purposes the takeoff mass of the Bell 206L-3 was adjusted from 1882 Kg to 1796 Kg in order to achieve the same rate of climb as the Bell 206L-1.

REFERENCE: Bell Helicopter rotorcraft flight manual information via a telephone-conference with Bell Helicopter.

**Figure 3.1.B**



### 3.2 CORE FLIGHT OPERATIONS

The following operations are the ICAO Annex 16 noise certification reference procedures (Chapter 8, Section 8.6). Participants were requested to include these operations in their flight programs. It was also requested that six "good" runs be acquired for each operation.

#### 3.2.1 Flyover Test Series

The overflight reference procedure, as stated in ICAO Annex 16, Chapter 8, Section 8.6.3, is as follows:

- the helicopter shall be stabilized in level flight overhead the flight path reference point at a height of 150 meters (492 ft);
- a speed of 0.9 VH or 0.9 VNE or 0.45 VH + 120 km/h ( $0.45 \text{ VH} + 65 \text{ kt}$ ) or  $0.45 \text{ VNE} + 120 \text{ km/h}$  ( $0.45 \text{ VNE} + 65 \text{ kt}$ ), whichever is the least, shall

be maintained throughout the overflight reference procedure;

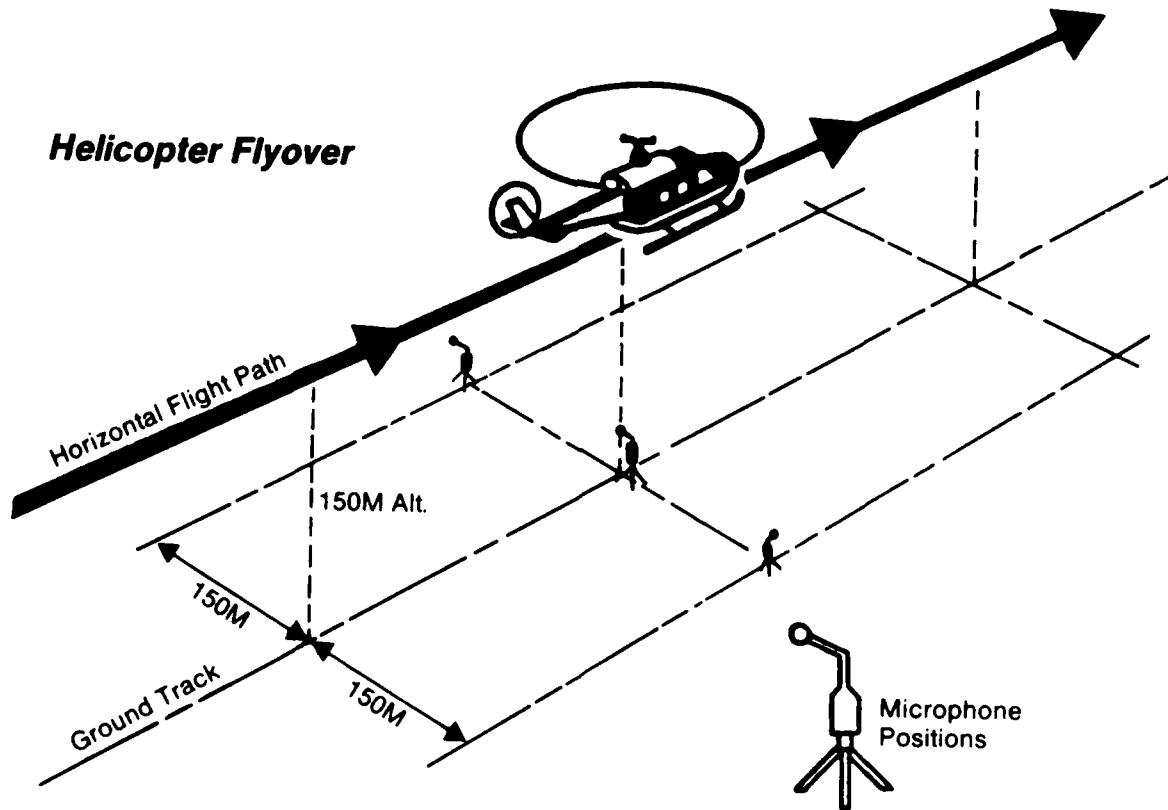
(Note: VH is the maximum speed in level flight at power not exceeding maximum continuous power. VNE is the never exceed speed.)

- c) the overflight shall be made with the rotor speed stabilized at the maximum normal operating rpm certificated for level flight;
- d) the helicopter shall be in cruise configuration; and
- e) the mass of the helicopter shall be the maximum takeoff mass at which noise certification is requested.

The reference airspeed selected for the level flyover operation was 117 knots, which is 0.9 VH.

This flyover operation is depicted graphically in Figure 3.2.A.

**Figure 3.2.A**



### 3.2.2 Takeoff Test Series

The takeoff reference flight procedure, as stated in ICAO Annex 16, Chapter 8, Section 8.6.2, is as follows:

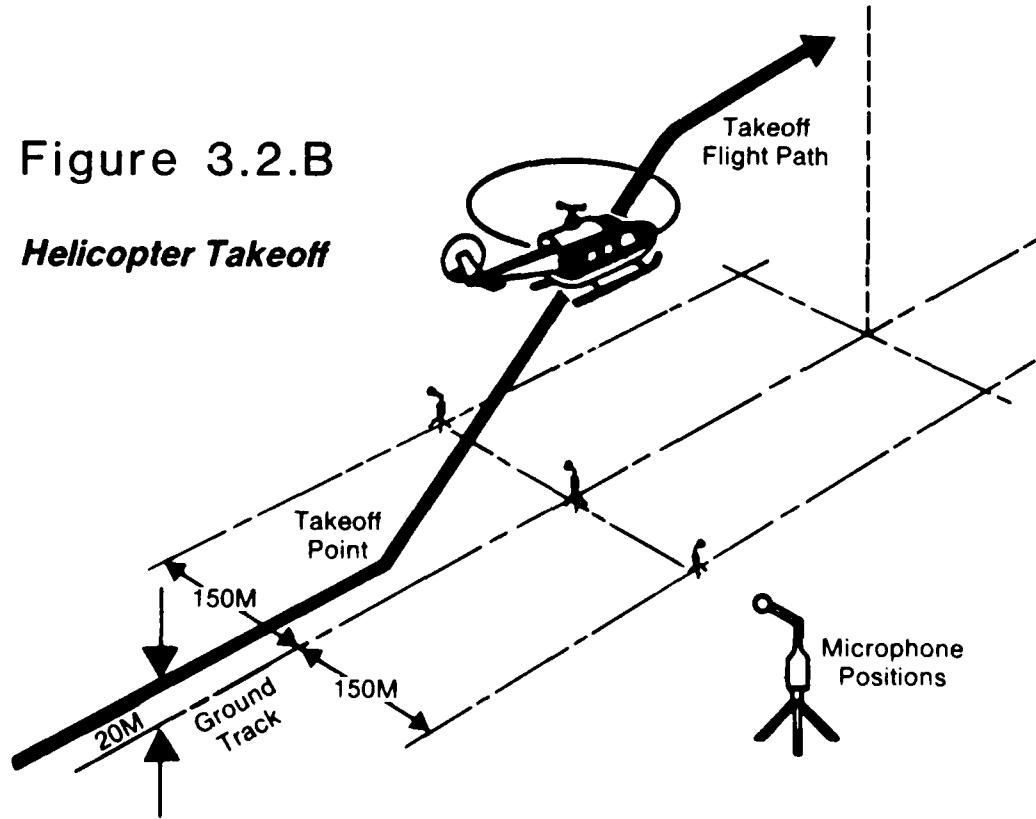
- a) the helicopter shall be stabilized at the maximum take-off power and at the best rate of climb along a path starting from a point located 500 m forward of the flight path reference point, at 20 m (65 ft) above the ground;
- b) the best rate of climb speed  $V_y$ , or the lowest approved speed for the climb after take-off, whichever is the greater, shall be maintained throughout the take-off reference procedure;
- c) the steady climb shall be made with the rotor speed stabilized at the maximum normal operating rpm certificated for take-off;
- d) a constant take-off configuration selected by the applicant shall be maintained throughout the take-off reference procedure except that the landing gear may be retracted; and
- e) the mass of the helicopter shall be the maximum take-off mass at which noise certification is requested.

The pilots were asked to anticipate the rotation marker and apply maximum takeoff power early so that the helicopter would intercept a direct climb path, projecting from the 500 meter rotation point, 20 meters above the ground.

This takeoff operation is graphically depicted in Figure 3.2.B.

**Figure 3.2.B**

***Helicopter Takeoff***



### 3.2.3 Approach Test Series

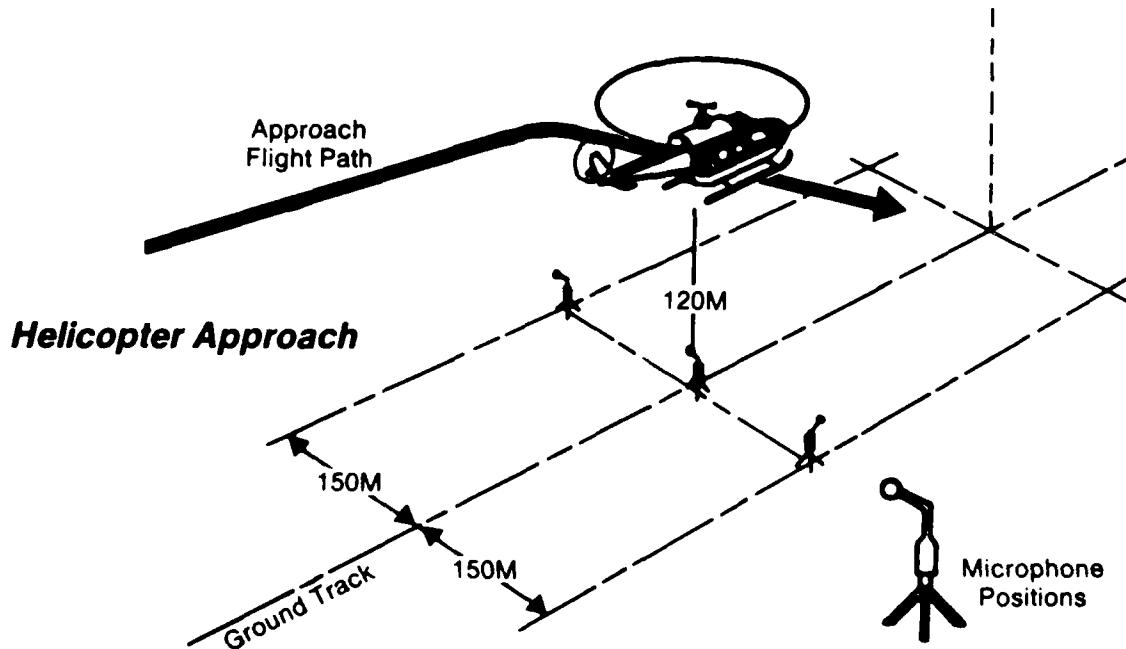
The approach reference procedure, as stated in ICAO Annex 16, Chapter 8, Section 8.6.4, is as follows:

- a) the helicopter shall be stabilized and following a 6 degree approach path;
- b) the approach shall be made at a stabilized airspeed equal to the best rate of climb speed  $V_y$ , or the lowest approved speed for the approach, whichever is the greater, with power stabilized during the approach and over the flight path reference point, and continued to a normal touchdown;
- c) the approach shall be made with the rotor speed stabilized at the maximum normal operating rpm certificated for approach;
- d) the constant approach configuration used in airworthiness certification tests, with the landing gear extended, shall be maintained throughout the approach reference procedure; and
- e) the mass of the helicopter at touchdown shall be the maximum landing mass at which noise certification is requested.

An airspeed of 57 knots was established as  $V_y$  for approach operations.

This approach operation is graphically depicted in Figure 3.2.C.

**Figure 3.2.C**



### 3.3 ELECTIVE OPERATIONS

The following operations were conducted at the option of the participants. Some of these test scenarios were delineated in the test plan, while others were selected by the test participants for the enhancement of their own programs.

#### 3.3.1 Higher Altitude Level Flyover Operations

In some programs additional flyover tests were conducted at 250, 300, and 350 meters following the procedures otherwise detailed for the certification flyover test.

#### 3.3.2 Speed Trials

Additional flyover test series were conducted at a variety of airspeeds (57, 83, 91, 94, 98, 104, 105, 110, 118, and 130 knots) following the procedures otherwise detailed for the certification flyover test.

#### 3.3.3 Bell Recommended Approach

This operation was conducted following a procedure developed by Bell Helicopter:

1. Commence approach from a level flight altitude of 750 feet AGL (above ground level). Follow a descent profile as if to land at the reference 6 degree target point, such that the central microphone is overflowed at 400 feet AGL. Terminate the descent at 100 feet AGL.
2. Start descent at 80 to 100 knots and reduce collective pitch to 10 to 20% main rotor torque.
3. Bleed off airspeed during the descent down to an altitude of 200 to 300 feet.

Note: The reduction in collective pitch to the 10 to 20% torque range will result in a higher than normal rate of descent. To offset this higher rate of descent, if desired, the approach may be started at 10 to 20% torque. This procedure should be practiced so that the pilot familiarizes himself with the variation in collective and cyclic controls necessary to tune out the main rotor's impulsive sound.

Presented in Section 8.2.6 is an analysis of Bell approach data versus ICAO 6 degree approach data.

#### 3.3.4 Six Degree Approach - No Guidance

This operation was intended to evaluate the potential problem of "over controlling" when following visual and verbal flight path guidance inputs.

The target operational procedures established in the US/Canadian program were as follows:

1. Maintain a stabilized rate of descent of 600 feet per minute.
2. Stabilize airspeed at Vy (57 knots).
3. Stabilize rotor speed at maximum (top of green arc) normal operating RPM (394 RPM).
4. Commence the descent at 750 feet AGL. Proceed with 6 degree descent such that the central microphone is overflowed at 400 feet AGL. Continue down to 100 feet AGL.

Results from the six degree approach - no guidance operations are compared to the ICAO six degree approach results in Section 8.2.5.

### 3.3.5 Core Repeated by a Second Pilot

In several of the programs, the core test program was conducted by two different pilots. This established the means to assess the influence of pilot technique. This comparison is discussed in Section 8.2.2.

### 3.3.6 ICAO Takeoff Variations

ICAO takeoff variation operations were flown in two of the flight test programs. In the French/Italian test an "early rotation" operation was tested and in the Japanese test a "power climb" as well as an early rotation operation were included.

### 3.3.7 Other Approach Operations

A variety of approach operations were included in the various flight test programs. Those not previously mentioned are:

|                    |                     |                  |
|--------------------|---------------------|------------------|
| Six degree Vy + 20 | Nine degree Vy      | Twelve degree Vy |
| Six degree Vy - 20 | Nine degree Vy + 20 |                  |
| Six degree Vy - 17 | Nine degree Vy - 17 |                  |

The results of some of these operations are examined in Section 8.2.6.

### 3.3.8 Static Operations

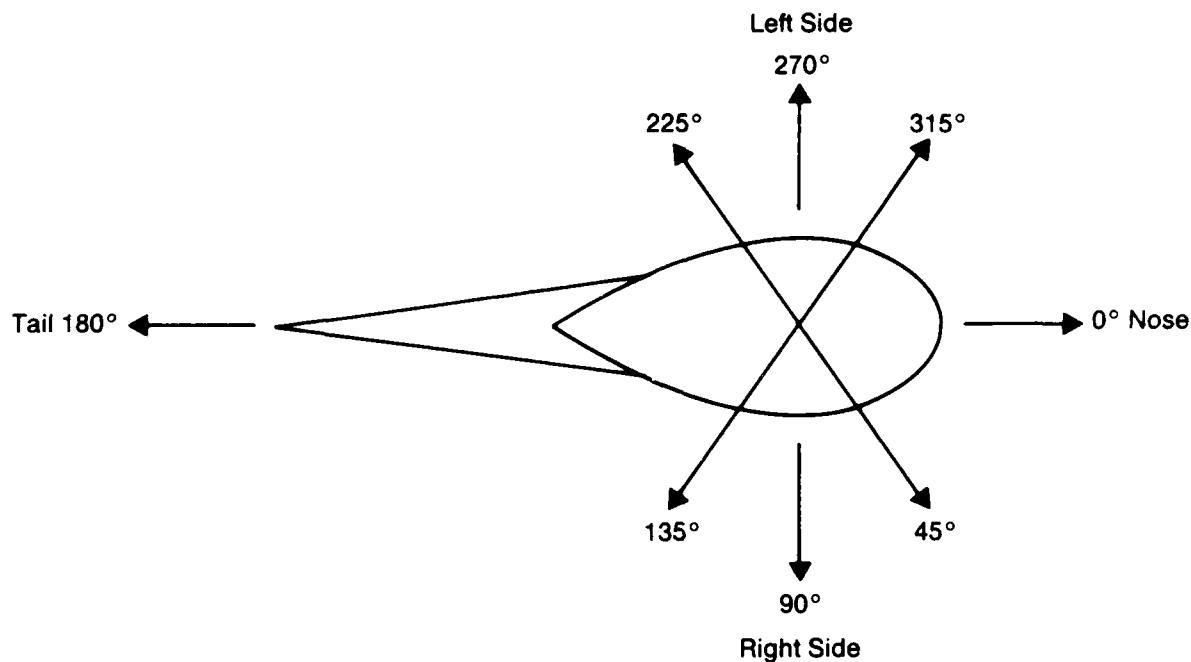
The static operational test series described below were intended to provide a test-to-test check on the similarity in acoustical emission characteristics with the effects of: pilot technique, forward flight, winds aloft, and propagation path anomalies removed.

During all static operations the helicopter was positioned at a designated point on a runway or taxiway. The measurement teams recorded a one minute (or longer) sample of sound for each of the eight directivity angles.

The acoustical emission angle convention for the HNMRP test was given as: zero degrees at the nose, 90 degrees off of the right side, 180 degrees at the tail, and 270 degrees off of the left side of the helicopter. Figure 3.3.A is a diagram of the acoustical emission angle convention.

## Figure 3.3.A

### ***Acoustical Emission Angle Convention***



The eight directivity angles were intended to provide an additional check on the helicopter source characteristics by allowing a direct comparison of directivity patterns. The requested 60 second sampling period was intended, in part, to smooth out effects of micro-meteorology.

Participants were encouraged, if possible, to include a second measurement site for all static operations conducted, the first site being located 150 m away from the helicopter over a hard propagation path. This second site was to be located 150 m away from the helicopter over a soft propagation path.

#### **3.3.8.1      Static Flight Idle**

For the static flight idle operation, the helicopter skids are on the ground and the rotor RPM is stabilized throughout the recording period at 100 percent RPM. The results of the static flight idle test series are discussed in Section 8.2.9.

#### **3.3.8.2      Static Ground Idle**

The static ground idle test target procedures are the same as those followed in the static flight idle, except that the target RPM is 67 percent.

### 3.3.8.3 Static Hover-In-Ground-Effect

The static hover-in-ground-effect (HIGE) test series is conducted such that the skid height is five feet above ground level (see Figure 3.3.B). All other target procedures are the same as for the flight idle static operations.

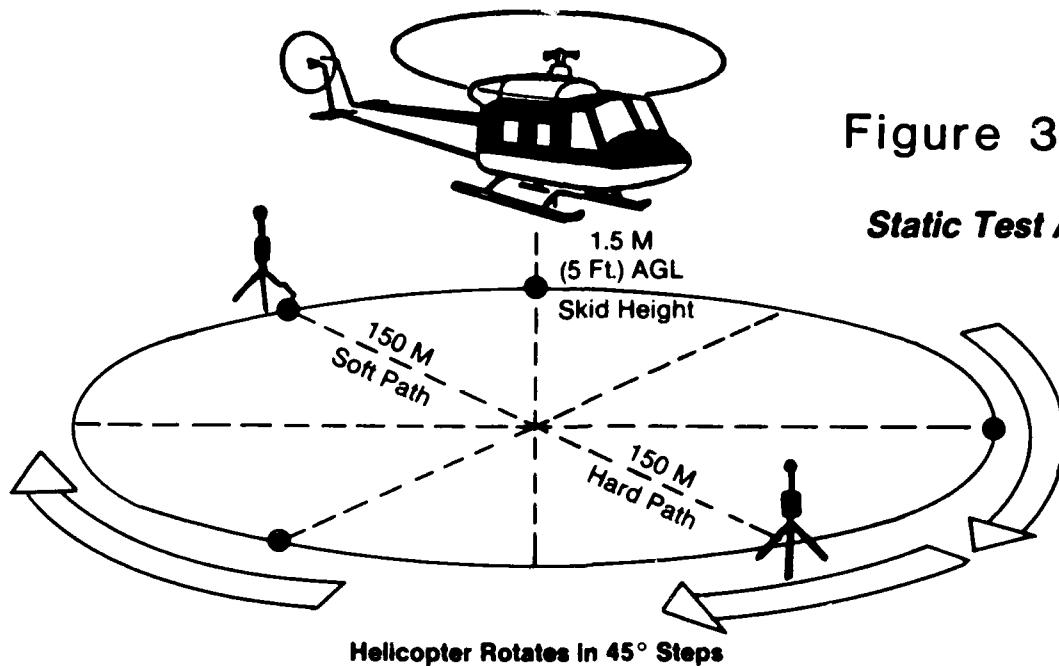


Figure 3.3.B

Static Test Array

### 3.4 DATA ANALYSIS SYSTEM CALIBRATION TEST TAPE

Inclusion of data analysis system calibration test tapes in the HNMRP came as an outgrowth of an earlier ICAO CAN WG B program. In 1980 and 1981, an international "round-robin" helicopter noise analysis program was conducted (ref 1) which performed a quantitative comparison of data reduction and analysis systems using analog tapes of helicopter noise. The program found that, on average, organization to organization differences were small. In the context of the repeatability program, however, analysis system test tapes were used to attempt to prepare a normalization process which would compensate, to the greatest extent possible, for the known (or knowable) sources of data reduction and analysis system variation. With this in mind, system comparison tapes were devised along the lines of the "round-robin" program tapes.

Identical test tapes were prepared by the US Department of Transportation (DOT) Transportation Systems Center (TSC). All of the tapes were recorded on a Nagra IV-SJ instrumentation tape recorder at a speed of 19 cps, and contained helicopter noise data and reference signals. Noise data were recorded on both channels 1 and 2, and an IRIG-B time code signal was recorded on the cue track.

The helicopter noise data on the tapes were measured at a centerline-center microphone location and had been modified by accentuating the high frequencies and by adding artificial high frequency noise to ensure a good signal-to-noise ratio from 10-dB-down-point to 10-dB-down-point. After analysis on the US system, the calibration tapes were distributed and analyzed by the ten laboratories participating in the program. The findings and results of these analyses are presented in Section 9.2.

#### 4.0 IMPLEMENTATION OF THE PROGRAM PLAN: TECHNICAL ISSUES AND DISCUSSIONS

The following section addresses a cross section of practical concerns, identified during the HNMRP, which arise when an individual or an organization actually goes into the field to implement a flight test program. As such, this section provides an excellent starting point for future ICAO efforts to develop a technical manual or guidance document for the implementation of the Annex 16 noise certification standards.

This section is organized by subject areas, pulling together information from the HNMRP test plan and combining it with comments and suggestions which were put forth by the program participants. These discussions include comments from the program test planning period and specifically detail noise certification test program implementation and data reduction concerns.

##### 4.1 GROUND SURFACE CHARACTERISTICS

Within the context of noise measurement repeatability, the question of ground surface characteristics has in the past been cited as a possible source of variability. This issue was addressed by the HNMRP by each team deploying a ground plane microphone at the centerline-center measurement site to complement the 1.2-meter microphone. (The data from these ground microphones are compared to the 1.2 meter microphone data in Section 8.2.8).

The observed differences in the noise levels between the microphones provide a measure of the impedance characterizing the ground surface. The difference, between the value measured at the ground and the value measured at the 1.2 meter microphone level,—at a fixed incidence angle—should be a qualitative indication of the acoustic reflective properties of the ground surface.

One participant, however, commented that the difference (ground minus 1.2 meter) could be misleading: "It was observed that the difference depended heavily upon the frequencies at which the tones were generated, as well as upon the ground surface impedance."

In response to this observation it should be noted that the object of assessing the differences between the 1.2 meter and the ground microphone sound levels is explicitly to quantify the aggregate influences of surface impedance and source spectral content. The object is not to suppress these effects, but to "let them operate," thereby documenting (to a degree) the test site impedance characteristics.

##### 4.2 TRACKING

It was specified in the test plan that each test use a tracking system capable of providing time-coded helicopter position information. It was also recommended that ground speed and climb and descent angles be identified for each event as an analytical aid.

When sophisticated continuous tracking systems prove to be unavailable the following two suggestions were proposed.

1. Equip the test helicopter with a radar altimeter (much more accurate than standard barometric altimeter).
2. Utilize photographic scaling techniques to quantify the helicopter altitude at three sites along ground track.

The specific tracking systems used in each test program are identified in Section 5.

#### 4.2.1 Photo Scaling

For the HNMRP, skid width--rather than rotor diameter--was taken to be the helicopter reference position for photo scaling. Previous experience has shown that the combined effects of the rotor blade conning and the rotor tilting create a foreshortened image of the rotor diameter. Referencing the skid width eliminates this problem.

For those using photo-scaling techniques, it was recommended that an electronic signal, activated by a camera shutter (or other) mechanism, be noted on the cue or auxiliary channel of the relevant acoustical recorder. This signal, assuming a constant airspeed, permits precise calculation of the PNLT<sub>m</sub> noise record.

When the electronic shutter signal technique was not used, the angle of the helicopter position at the time of PNLT<sub>m</sub> was assumed.

#### 4.3 COCKPIT INSTRUMENT READINGS

The test plan specified that some method be used to record the flight instrument readings for each event. Targeted parameters specified were: torque, indicated airspeed, rotor RPM, rate of climb or descent, time over the centerline-center site, and the radar altimeter reading (barometric altitude, if no radar).

Given time and space limitations for this report, and the irregular reporting of this information, the cockpit observer's log data have not been examined and are not included in this report. These data, however, do provide a possible stepping stone for future studies concerning variations in the multi-nation results.

#### 4.4 WIND DATA

At the outset of the program, it was suggested that if possible wind data at the test flight altitudes be acquired to supplement the usual 10 meter (33 foot) temperature and relative humidity readings. Recommended wind data acquisition techniques included tethered balloons, meteorological radiosondes, or acoustical sounding devices.

It was further recommended that temperature, relative humidity, wind speed, and wind direction data be acquired at increments of 30.5 meters (100 ft) between the ground and an altitude of 305 meters (1000 ft) above the ground.

Concerning wind conditions, one program participant commented that testing should be carried out at low wind speeds and suggested that specific limits should be defined. "Assuming that pilots maintain the correct air speed and glide slope during the approach, head winds will reduce the rate of descent with possible marked changes in the noise characteristics. The effect of both wind speed and direction will, however, vary with helicopter type and we would suggest that suitable limits be recommended."

The concern that wind be as low as possible was strongly shared among the participants; a maximum of 5 knots (total wind vector) was thus, for the purposes of the HNMRP, taken to be an acceptable limit. Although current authorities have not agreed on a "magic number" for minimum wind speed, 5 knots was used in the program because it is generally given as the maximum speed for "light and variable" wind conditions.

#### 4.5 APPROACH GUIDANCE

The use of a Visual Approach Slope Indicator (VASI), Precision Approach Path Indicator (PAPI), or equivalent was recommended for use in assisting approach operations.

One participant commented:

"In our experience, attempts by the pilot to fly down a very narrow PAPI beam produce a continuously varying rate of descent. Thus, while the mean flight path is maintained within a reasonable degree of test precision, the rate of descent (an important parameter connected with blade/vortex interactions) at any instant in time may vary much more than during operational flying. It is believed that in certain circumstances, precision visual guidance systems may exacerbate blade slap problems and would suggest that each organization should carry out approaches with and without visual guidance."

Following this suggestion and previous concerns, it was recommended to all participants that they include in their programs an approach operation conducted entirely "on instruments." During this operation the rate of descent and airspeed were monitored in order to achieve the reference approach path.

As discussed in later sections of this report, guidance technique was not seen as a significant factor in noise level variability for the particular test helicopter.

#### 4.6 STATE OF MAINTENANCE

As an additional test design control, it was recommended that the participants document the general condition of the test aircraft and determine the time since its last overhaul. It was considered plausible that differences in overhaul status could influence resulting noise levels.

#### 4.7 DATA ACQUISITION SYSTEMS

The test plan provided general guidance with respect to measurement hardware. In Section 5 of this report the equipment used by each test team is discussed in detail.

#### 4.8 ANALYSIS SYSTEM TIME CONSTANT

During the initial program planning period, one participant commented:

"I do not accept that (as stated in the HNMRP test plan) 'strict adherence to IEC-179, -161, -225, and -651 requirements ....' will necessarily ensure that the results will be free from hardware bias errors. WHL have presented (UK WP10, May 1981, Ref.A) results of tests showing that the presence of impulsive signals does introduce hardware related variability. These findings were confirmed by further tests carried out on three types of analyzers...(UK WP2, December 1981, Ref.B) and...(US letter report DOT-TSC-FA-253-LR-2, October 1981. Ref.C). For whatever reason, WHL have obtained differences of more than 0.5 EPNdB when analyzing the same tape recording on GEN RAD 1995 and 1921 machines. In the context of the proposed tests, I suggest that we should at least acknowledge a potential source of hardware variability and make due allowance in the interpretation of the results." (Ref 9).

The issue of system dynamic response was subsequently pursued by the HNMRP.

Participants using the GEN RAD 1995 were henceforth requested to use the "1-second exponential integration" setting, and those using the B&K 2131 to select the "2-second exponential averaging" setting each equivalent to a slow exponential dynamic response. In the case where a linear detection is utilized, participants were also requested to employ a weighted moving window function designed to achieve a response closely duplicating that of the slow exponential.

Refinements to Annex 16 concerning this issue are discussed in Section 6.5.1.

#### 4.9 ADVANCING BLADE TIP MACH NUMBER CORRECTION

In accordance with Annex 16, the HNMRP test plan stated that participants should apply the "Delta 3" advancing blade tip Mach number correction to level flyover data. The procedure to implement airspeed-temperature source noise adjustments was outlined as follows:

- a. Develop a function of PNLT<sub>M</sub> versus advancing blade tip Mach number.
- b. Plot the noise data and determine a best curve fit function to the data.
- c. Use the local slope of the function to correct all data back to the reference airspeed and temperature.

#### 4.10 SPECTRAL IRREGULARITIES

Participants were reminded that tone corrections are to be computed using the acoustical spectrum extending from 50 Hertz (band 17 low edge) to 11,200 Hertz (band 40 edge) in accordance with ICAO Annex 16, Appendix 4, Sections 4.3 and 4.4. The initiation of the tone correction procedure at a lower frequency reflects recognition of the strong low frequency tonal content of the helicopter noise.

#### 4.11 SPECTRAL SHAPING

Spectral shaping techniques were reviewed in the Mid-Program Review document as follows:

In the event that the signal to noise ratio in a given one-third octave band is less than 3 dB, the band SPL is said to be masked. In this case it is necessary to implement the spectrum normalization procedure set out in the CAN Seven, Report on Agenda Item 3, pages 3-53 and 3-54 (Ref 10). In the event that tracking or meteorological data are unavailable, it is recommended that a slope of 3 dB per one-third octave be utilized.

This value (3 dB per one-third octave) was based on examination of preliminary 206L-1 data acquired in the US/Canadian test program.

#### 4.12 STATIC TESTING

Static tests were included in the HNMRP test plan because static operations are typically encountered in heliport operations. The HNMRP imposed 60 second sampling period (discussed in Section 4.12) was requested in an effort to acquire a representative measure of the acoustical source characteristics--including random temporal variation.

Concerning the static test, one participant expressed concern that "Noise levels measured during hover, particularly at very low altitudes can vary tremendously--15 dB(A)--in a single 30 second period." In response to this concern it was recommended that the 60-second samples be broken down into 2-second sample periods and the LEQ be calculated for each 2-second sample. This additional measure will tend to identify source variability and provide another figure of merit for test-to-test comparisons.

The multi-nation comparison of static data is discussed in Section 8.2.9.



## 5.0 INDIVIDUAL TFST PROGRAM SUMMARIES

Independent programs were conducted by Australia and Japan, while joint programs were conducted by: France DGAC Service Technique de la Navigation Aerienne (STNA), France Aerospatiale and Italy; the United Kingdom (UK) and the Federal Republic of Germany (FRG); and the United States (US) and Canada. (In the listing of joint programs, the host team is listed first.)

Where possible, excerpts have been taken directly from participants' reports. Descriptions of equipment and processes utilized by each team have been included, in as much detail as possible, so that readers planning tests will benefit from the experience of the HNMRP participants. (The reports have not been reproduced in their entirety for space conservation purposes.)

In all tests problems do arise. Some of those problems are described in the following sections for the benefit of anyone planning a similar test and for those planning further analyses with the HNMRP data. The following participant test summaries cannot, however, totally replace the participants' reports for conducting in depth examination of HNMRP data.

In regards to future analyses with HNMRP data, a GREAT deal of care must be taken when examining data in the individual participants' reports. Each participant submitted a number of different papers and reports. Some of these reports present only as measured data, some concern only a portion of their program, and some include data revisions. As such, the most current data set for each participant is not necessarily in their most recent submission. A list of the participants' submittals can be found in the reference section of this report, just prior to the appendices.

In preparing this report the HNMRP Program Coordinator's Staff has gone to great lengths to attempt to get all of the numbers right. However, given the number of reports submitted, the variety of different reporting formats, language barriers, and numerous other problems there may yet be errors.

Below is a summary table of the HNMRP, Table 5.0.A. Included in the table is a list of those who participated in the HNMRP, both certificating authorities and manufacturers. This list includes Brazil which acquired certification experience by performing a practice noise test, but was unable to participate in a full repeatability noise test program.

## Table 5.0.A

### ICAO HELICOPTER NOISE MEASUREMENT REPEATABILITY PROGRAM

#### NATIONS WHICH ACQUIRED CERTIFICATION EXPERIENCE:

AUSTRALIA  
BRAZIL  
CANADA  
FRANCE  
FEDERAL REPUBLIC OF GERMANY  
ITALY  
JAPAN  
UNITED KINGDOM  
UNITED STATES

#### NOISE MEASUREMENT - FLIGHT TEST PROGRAMS CONDUCTED (in chronological order):

|           |             |  |
|-----------|-------------|--|
| July      | 2- 6, 1984  | UNITED KINGDOM - FEDERAL REPUBLIC OF GERMANY |
| August    | 27-29, 1984 | UNITED STATES - CANADA                       |
| September | 13-14, 1984 | AUSTRALIA                                    |
| October   | 16-17, 1984 | FRANCE STNA - FRANCE AEROSPATIALE - ITALY    |
| December  | 1- 2, 1984  | JAPAN  |

#### AIRCRAFT & HELICOPTER MANUFACTURERS WHO PARTICIPATED IN TESTING & EVALUATION:

AEROSPATIALE  
AGUSTA  
BELL TEXTRON  
BRITISH AEROSPACE  
DE HAVILLAND OF CANADA  
KAWASAKI  
SIKORSKY  
WESTLAND

TOTAL NUMBER OF FLIGHT TEST RUNS CONDUCTED: 529

## 5.1 AUSTRALIAN TEST PROGRAM

The Australian test program was conducted by the Australian Department of Aviation, Airways Division at Mangalore Airfield in Victoria, Australia on the 13th and 14th of September 1984. Mangalore is approximately 100 km north of Melbourne. Taking into account their geographical location, the Australians found it impractical to arrange for a joint program with another nation.

### 5.1.1 Weather

Since the tests were scheduled for the end of the Australian winter, suitable weather was a very important concern. The 13th, however, proved to be a fine, still morning with no frost, light winds and little cloud cover. The following test day was calm and significantly colder, with visible ground frost. That day there was a delay, however, to allow the temperature to stabilize as the frost melted. All in all, the weather for the tests was fine and sunny.

### 5.1.2 Operations

The Australian test program included the ICAO certification level flyover, approach and takeoff as well as:

117 kts level flyover operations at 250 and 350m;  
150m level flyover operations at 104 and 91 kts;  
six degree approaches at 40 and 77 kts;  
the Bell "Quiet" approach operation;  
a six degree approach without guidance; and  
a static flight idle operation

### 5.1.3 Pilot

Flight test operations were performed by a single test pilot.

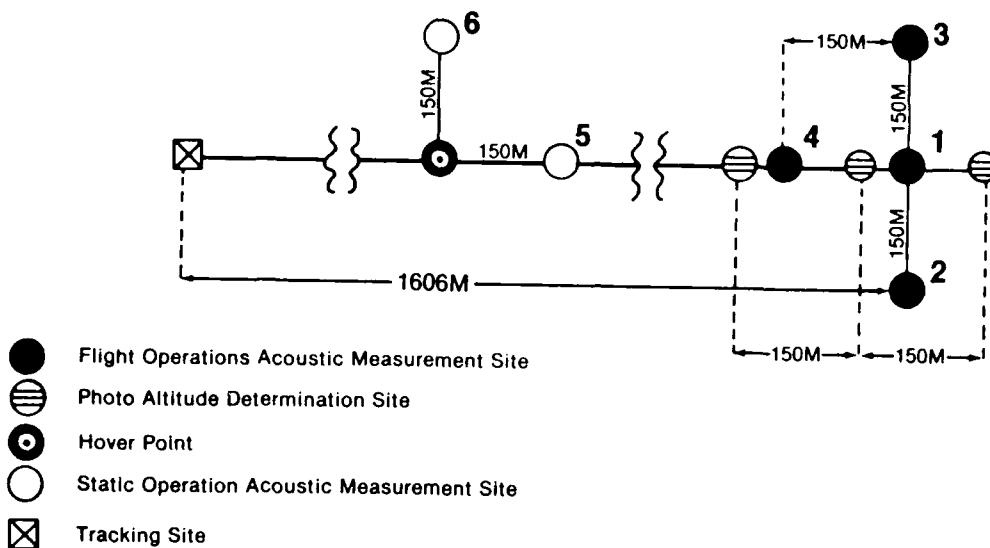
### 5.1.4 Test Helicopter

The test helicopter used during the Australian test was a Bell 206L-1. Table 5.1.A is a summary of the information available concerning the particular helicopter tested.

### 5.1.5 Test Site Array

The Australian flight operations test site array, shown in Figure 5.1.A, consisted of the three certification measurement sites and the additional centerline site requested in the HNM RP test plan. For the static test there were the two requested sites located 150m away from the hover site, one over a hard propagation path, the other over a soft propagation path. The three photographic sites were placed in line with the centerline path at 150m intervals.

**Figure 5.1.A**  
**Australian Test Site Array**



**Table 5.1.A**

|                     |                  |
|---------------------|------------------|
| Registration Number | VH BJV           |
| Serial Number       | 45387            |
| Engine              | Allison 250-L28B |

**Maintenance History**

|                          |            |
|--------------------------|------------|
| Engine                   | 1482 hours |
| Rotor hub                | 1482 hours |
| Rotor hub since overhaul | 282 hours  |
| Rotor                    | 1482 hours |
| Transmission             | 1482 hours |

### 5.1.6 Equipment

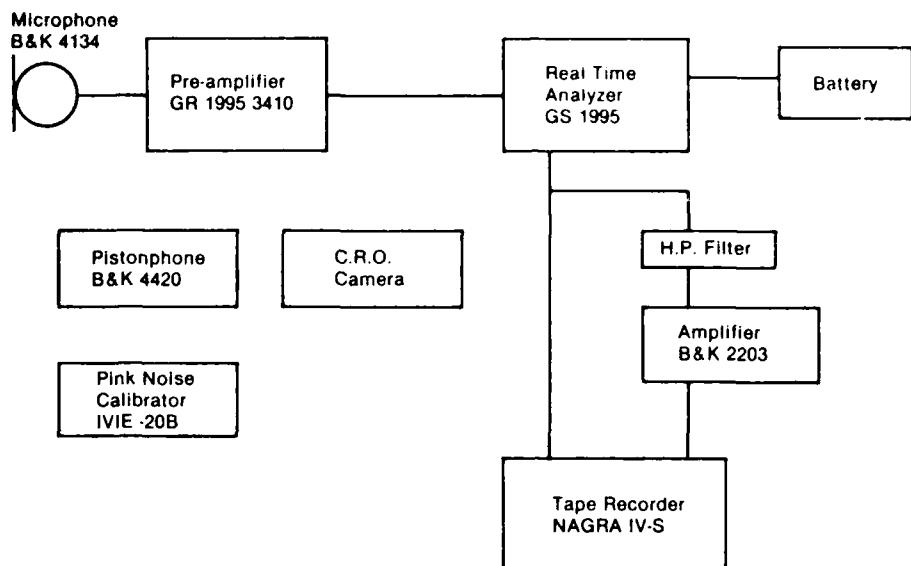
#### 5.1.6.a Acoustic Equipment

A dual microphone system was deployed by the Australian team at their centerline-center site. This equipment, shown in Figures 5.1.B and 5.1.C, sent 1.2 m microphone data to one track of the Nagra recorder and ground microphone data to the other track. Single microphone systems were used at all of the other noise measurement sites.

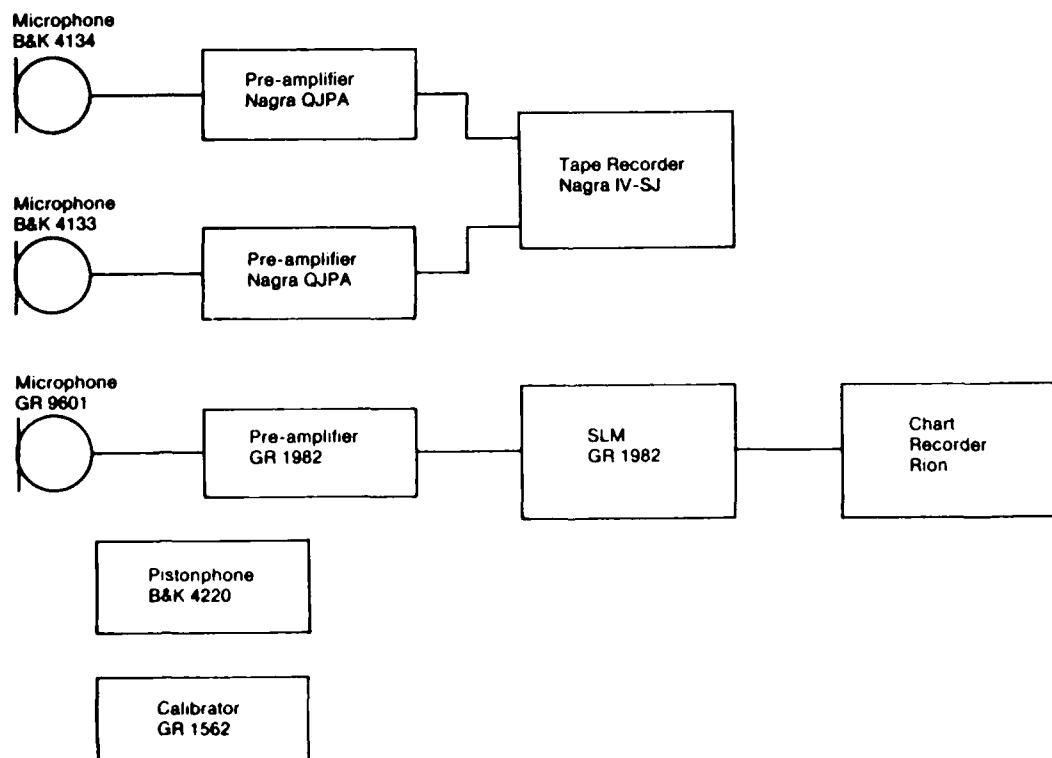
All equipment used in the measurements was, whenever possible, calibrated and was tested in accordance with ISO Standard 3891 or to standards referenced in ISO 3891, principally IEC Standard 561.

**Australian Noise Measurement/Recording System Instrumentation**

**Figure 5.1.B**



**Figure 5.1.C**



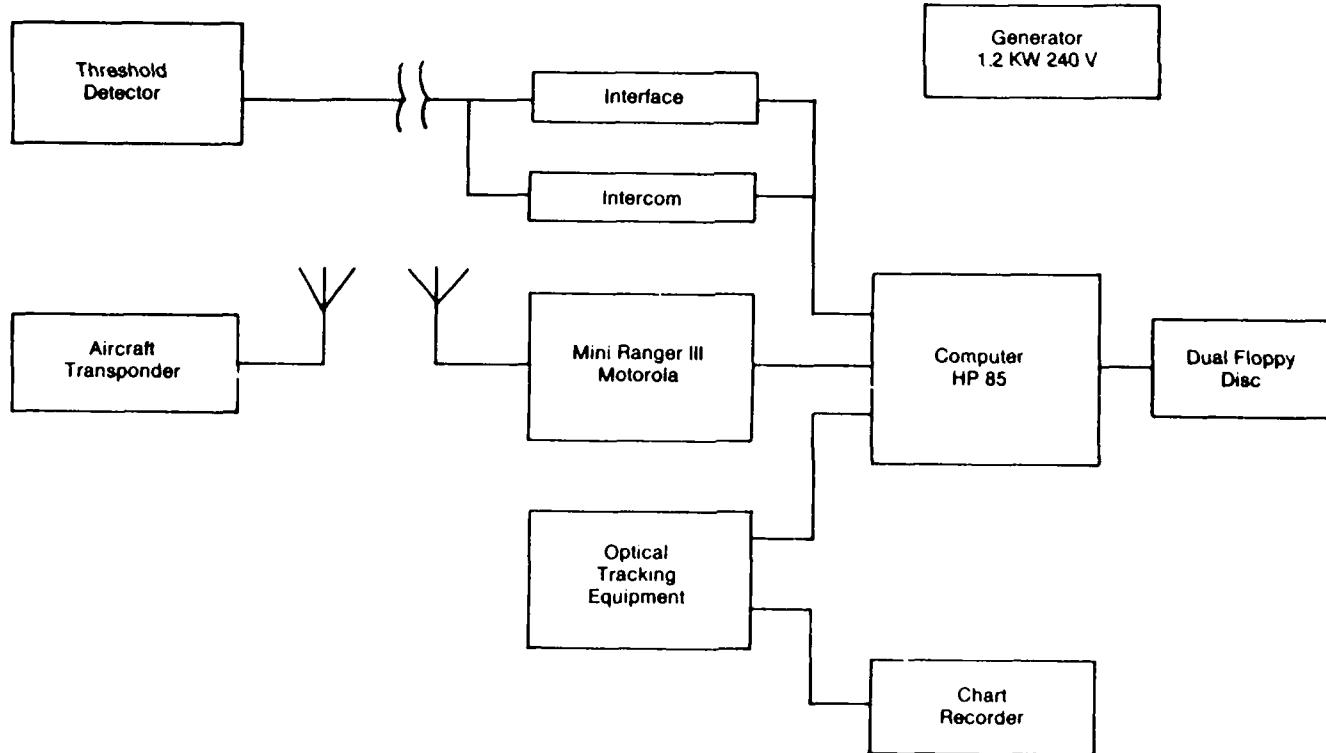
Sound level meters were tested in accordance with Australian Standard AS 1259-1982 based on IEC 651. The B&K type 2203 meters used were built to conform to a previous standard (IEC 179) and were not able to strictly conform to the detection requirements of IEC 651. The B&K 2204 meters failed to meet the noise level requirements on the lowest scale. Since the tests were not dependent on these functions of the instruments, the units were considered satisfactory for the tests.

#### 5.1.6.b Tracking Equipment

The tracking system used during the Australian test program, shown in Figure 5.1.D, was developed by the Australian Department of Aviation, Airways Division Systems Branch and was composed entirely of existing Australian Department of Aviation equipment. The optical electronic tracking equipment used in the system was originally developed to test Instrument Landing Systems. As modified this equipment provided a readout of azimuth and elevation angles at a rate of 20 samples per second. The unit can electronically track a light mounted in the aircraft, however, during this test program it was used in the manual mode.

**Figure 5.1.D**

**Australian Aircraft Tracking System**



For tracking, a small transponder unit (part of the radar distance measuring Mini Ranger III) was placed in the aircraft and was powered by the aircraft's

auxiliary supply. This unit, uses a small external antenna on the aircraft to transmit to a horn antenna on the receiver-transmitter-measuring unit located at the tracking site.

A threshold detector was also used as part of the tracking system. Situated at the centerline-center site, it put a short on the telephone line to the tracking site when the aircraft passed through the vertical fan-shaped beam. The time of this event was detected by the instrument at the tracking site and recorded. The time over centerline-center was also independently available from the distance measuring equipment at the tracking site.

#### 5.1.6.c Photo Altitude Determination System

The tracking equipment described above was an untried system with unknown reliability in the field. It was therefore considered necessary to have a fairly good back-up system. A photo-scaling system similar to the one described in the US FAA reports on helicopter noise measurements was used.

#### 5.1.6.d Meteorological Equipment

The Australian Bureau of Meteorology was responsible for measuring atmospheric conditions during the tests.

Continuous wind measurements were made throughout the trial period at a height of 10 meters using a Lambrecht Woelfle anemograph. This gave a continuous record of wind direction and wind run. Wind speed was derived from wind run.

At ground level, one meter, measurements of temperature and humidity were also taken.

Upper atmosphere data was obtained from instrumentation carried by a tethered balloon which was reeled up and down between the ground and 300 meters. Additional measurements up to a height of 2000 meters were made using a radio sonde. Both the tethered balloon and the radio sonde were tracked with a theodolite. The position of the tethered balloon was calculated from the theodolite angles and the length of tether line. The position of the radiosonde was calculated from the theodolite angles and height information derived from the temperature and pressure records.

#### 5.1.6.e Cockpit Data Documentation

A color video recorder and camera were used to record the instrument readings on the pilots console during the tests. The camera was a normal commercial unit with a built-in timer which was used to synchronize the helicopter instrument readings with the tracking and noise measurement results.

#### 5.1.7 Noise Data Reduction

The initial analysis of the Australian acoustic tapes was carried out on a system which consisted of: a GR 1925 Multifilter, a GR 1926 Multichannel KMS

Detector and a PDP11 computer. This system, however, failed several times, so an alternative system was developed using a GR1995 real time analyzer and a Hewlett Packard HP85 computer. Unfortunately, this second system gave EPNL values approximately 1dB lower than the initial system.

While investigating the cause of the discrepancy between the two systems, the initial system was restored. It was decided to continue the analysis on the initial system in the hopes that the analysis would basically remain valid and a correction factor could be applied if it was found to be in error.

Fortunately, before the next failure of the initial system occurred the normalization test tapes from the HNMRP program coordinator were analyzed. The results of this analysis confirmed the differences between the two systems and it was concluded that the fault lay with the initial system. Subsequently, the final Australian data set was obtained using the GR1995/HP85 system.

#### 5.1.8 Final Data Summary

The data in the "Australian Final Data Summary Table" (Table 5.1.B) came from the April 1986 Australian Submittal with the exception of the Tone Correction Values which came from the Australian June 1986 Telex. The three microphone average was calculated for all metrics and operations by the Program Coordinator's Staff using individual event data reported in the April 1986 Submittal.

# Table 5.1.B

FINAL CORRECTED AUSTRALIAN DATA

|                       | LEFT  | CENTER | RIGHT | 3MIC  | STD.DEV. | 90% CI |       |      |
|-----------------------|-------|--------|-------|-------|----------|--------|-------|------|
| <hr/>                 |       |        |       |       |          |        |       |      |
| APPROACH              |       |        |       |       |          |        |       |      |
| EPNL                  | 87.46 | 93.82  | 91.51 | 90.93 | 0.98     | 0.66   |       |      |
| PNLT <sub>m</sub>     | 86.47 | 93.83  | 91.39 | 90.57 | 1.11     | 0.74   |       |      |
| AL <sub>m</sub>       | 71.95 | 80.90  | 77.99 | 76.92 | 1.11     | 0.74   |       |      |
| SEL                   | NA    | NA     | NA    | NA    | NA       | NA     |       |      |
| LEVEL FLYOVER         |       |        |       |       |          |        |       |      |
| EPNL                  | 89.82 | 89.89  | 87.42 | 88.65 | 0.72     | 0.39   |       |      |
| PNLT <sub>m</sub>     | 90.16 | 92.22  | 88.30 | 89.23 | 0.61     | 0.33   |       |      |
| AL <sub>m</sub>       | 75.89 | 78.27  | 74.74 | 76.24 | 0.56     | 0.31   |       |      |
| SEL                   | NA    | NA     | NA    | NA    | NA       | NA     |       |      |
| TAKEOFF               |       |        |       |       |          |        |       |      |
| EPNL                  | 87.99 | 89.55  | 87.63 | 88.35 | 0.39     | 0.17   |       |      |
| PNLT <sub>m</sub>     | 98.97 | 90.39  | 88.21 | 89.18 | 0.48     | 0.21   |       |      |
| AL <sub>m</sub>       | 73.72 | 75.90  | 74.14 | 74.58 | 0.62     | 0.27   |       |      |
| SEL                   | NA    | NA     | NA    | NA    | NA       | NA     |       |      |
| DURATION P            |       |        |       |       |          |        |       |      |
| APPROACH              | 33.59 | 22.19  | 24.50 |       |          |        |       |      |
| LEVEL FLYOVER         | 20.86 | 14.27  | 23.18 |       |          |        |       |      |
| TAKEOFF               | 21.44 | 17.66  | 23.44 |       |          |        |       |      |
| DURATION A            |       |        |       |       |          |        |       |      |
| APPROACH              | 38.38 | 24.12  | 31.25 |       |          |        |       |      |
| LEVEL FLYOVER         | 22.59 | 15.04  | 24.05 |       |          |        |       |      |
| TAKEOFF               | 26.09 | 21.88  | 25.84 |       |          |        |       |      |
| TONE CORRECTION VALUE |       |        |       |       |          |        |       |      |
| APPROACH              | 1.54  | 0.96   | 1.65  |       |          |        |       |      |
| LEVEL FLYOVER         | 1.55  | 1.54   | 1.47  |       |          |        |       |      |
| TAKEOFF               | 2.53  | 2.01   | 2.47  |       |          |        |       |      |
| TONE CORRECTION BAND  |       | NA     |       |       |          |        |       |      |
| MAX NOY BANDS         |       | NA     |       |       |          |        |       |      |
| <hr/>                 |       |        |       |       |          |        |       |      |
| STATIC FLIGHT IDLE    |       |        |       |       |          |        |       |      |
| HARD                  | 0     | 45     | 90    | 135   | 180      | 225    | 270   | 315  |
|                       | 72.2  | 72.00  | 74.50 | 72.20 | NA       | NA     | NA    | NA   |
| SOFT                  | 66.8  | 70.80  | 67.00 | 63.90 | 64.80    | 64.20  | 70.20 | 71.2 |

DATA CAME FROM THE APRIL 1986 PARTICIPANT SUBMITTAL WITH THE EXCEPTION OF THE TONE CORRECTION VALUES WHICH CAME FROM A JUNE 1986 TELEX.  
THE 3 MIC AVERAGE WAS CALCULATED FOR ALL METRICS AND OPERATIONS BY THE PCG USING INDIVIDUAL EVENT DATA REPORTED IN THE APRIL 1986 SUBMITTAL.



## 5.2 JAPANESE TEST PROGRAM

The Japanese flight tests took place on the 1st and 2nd of December, 1984 at Utsunomiya Airport, 100 km north of Tokyo. The program was planned and coordinated by the Aircraft Nuisance Prevention Association of Japan.

### 5.2.1 Weather

The weather was generally cloudy both test days, with temperatures ranging from 7.8 to 14.9 degrees Celsius.

### 5.2.2 Operations

The Japanese flight test program consisted of 96 flights and 4 ground static noise measurements. Table 5.2.A is a list of the operations conducted.

**Table 5.2.A**

Japanese Test Program Flight Operations

| Operation             | Pilot | ID | Operation          | Pilot | ID |
|-----------------------|-------|----|--------------------|-------|----|
| ICAO Flyover          | A     | C1 | ICAO Takeoff       | A     | A1 |
| ICAO Flyover          | B     | C2 | ICAO Takeoff       | B     | A2 |
| ICAO Flyover Repeated | A     | D1 | ICAO 6 Approach    | A     | B1 |
| ICAO Flyover Repeated | B     | D2 | ICAO 6 Approach    | B     | B2 |
| 0.8 Vne Flyover       | A     | F1 | 6 degree Approach  |       |    |
| 0.7 Vne Flyover       | A     | G1 | No Guidance        | B     | E2 |
| 80m Vh Flyover        | A     | J1 | Static Ground Idle | K     |    |
| 80m Vh Flyover        | B     | J2 | Static Flight Idle | L     |    |
| 300m Vh Flyover       | B     | H2 |                    |       |    |

It should be noted that although the target flyover procedure called for 0.9 Vne (117 KIAS) and maximum continuous rpm (100%), the helicopter speed during the flyover operations were conducted at Maximum Continuous Power (85%) because the torque would have exceeded the airworthiness limitation (85%) (which has no time limitation).

### 5.2.3 Pilots

The core test program was performed by two pilots. Pilot A had 6,240 hours of flight time, while Pilot B had 1,810 hours. Included in Table 5.2.A are notations as to which pilot performed each operation.

#### 5.2.4 Test Helicopter

The Japanese test helicopter was a Bell 206L-3. The Japanese were the only team to test the L-3 variation. Details of the particular helicopter tested appear in Table 5.2.B. A comparison of the general specifications of the Bell 206L-1 and L-3 appears in Table 3.1.A. As discussed in Section 3.0, the two helicopters are acoustically identical.

Before each event, the weight of the helicopter was adjusted to the specified weight (1,796 Kg  $\pm$  5%). During the flight test, fuel was supplied after each 100 Kg fuel consumption and at the same time the weight of the helicopter was re-adjusted using ballast.

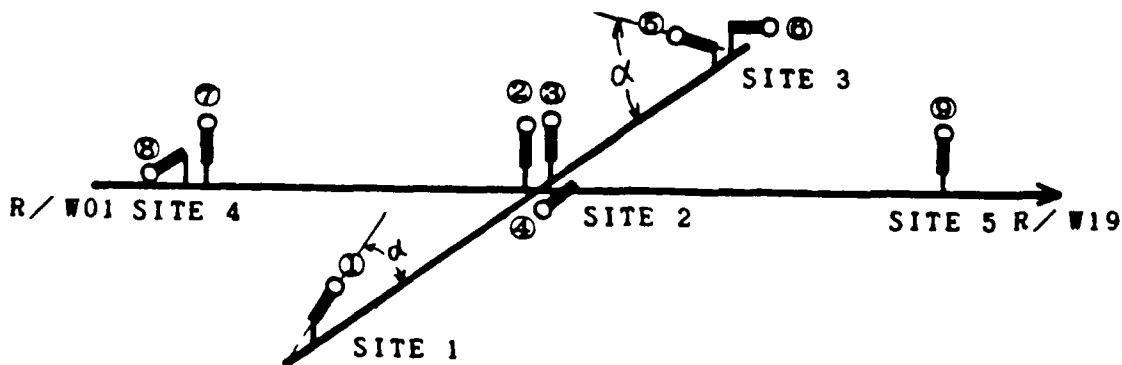
**Table 5.2.B**  
HELICOPTER DETAILS

|                                   |                  |                             |
|-----------------------------------|------------------|-----------------------------|
| Helicopter Model                  | Bell 206L-3      |                             |
| Registration Number               | JA9361           |                             |
| Serial Number                     | 51028            |                             |
| Engine                            | Allison 250-C30P |                             |
| Maintenance Status                | Cycle            | Time Since Last Maintenance |
| Track & Balance of Rotor System   | 100 Hr X 1       | 4.10                        |
| Power Plant                       | 100 Hr X 1       | 4.10                        |
| Rotor Hub                         | 100 Hr X 1       | 4.10                        |
| Transmission                      | 100 Hr X 1       | 4.10                        |
| Hours of Use (as of Dec. 1, 1984) |                  |                             |
| Power Plant                       | 94:13            |                             |
| Body                              | 99:13            |                             |

#### 5.2.5 Test Site Array

Figure 5.2.A is a diagram of the Japanese test site array. The ground surface of the test area was generally flat and covered with short cropped grass.

**Figure 5.2.A**



The acoustical measurement sites for flight operations consisted of three centerline sites (5, 2 and 4) and two sideline sites (1 and 3). The centerline-center site was equipped with a ground and a 1.2 m microphone. Sideline site 1 and centerline site 5 were each equipped with a single 1.2 m microphone. Sideline site 3 and centerline site 4 were equipped with two 1.2 m microphones. (The microphone array and equipment used are discussed further in Section 5.2.6.f.)

The test site array for static operations consisted of hard and soft propagation path sites at a distance of 150 m from the hover site.

The takeoff rotation point was located 500m from the centerline-center site. Visual cues to define the point were provided in the form of a red "X" and white lines. To assist the pilots in maintaining the centerline flight path, red and white lines were also provided at various positions along the centerline.

## 5.2.6 Equipment

### 5.2.6.a Approach Guidance System

To provide visual guidance during the approach operations, a standard Precise Approach Path Indicator (PAPI) system was used. The PAPI was located 1,140m from the centerline-center microphone position. Due to the short distance from the PAPI lights to the helicopter during the test, only two of the PAPI's four standard light units were used. The two light units were located 2.5 m to the left and right of the centerline. The pilots saw a red or a white light depending on the helicopter's position. The system used provided vertical displacement information within  $\pm 0.25$  degree of the reference approach slope.

### 5.2.6.b Photo Altitude Determination System

The system used was in accordance with the standard photo altitude determination systems used in the Australian HNMRP test and US FAA tests.

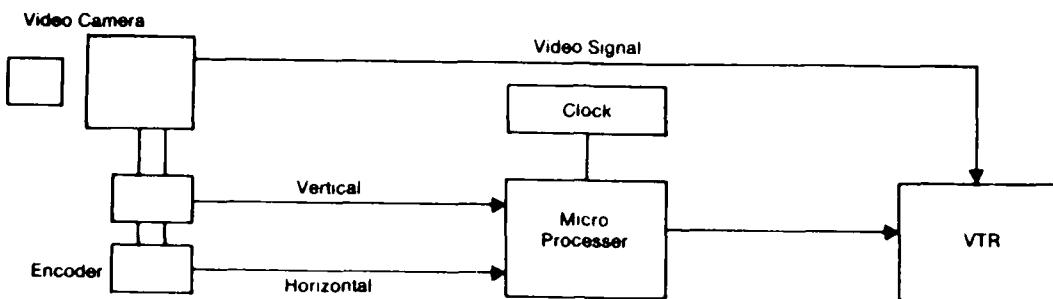
### 5.2.6.c Video Tracking System

Continuous tracking information was gathered using a video recording system (shown in Figure 5.2.B) that employed two video cameras. The helicopter was tracked by the cameras throughout each event and the relative helicopter position was measured by angles of elevation and azimuth from the position of each video camera unit. This information was recorded on a VTR tape at one-second intervals.

Calibration of the tracking system was performed several times using a static object of known height and distance. The accuracy of height was  $\pm 1.0\%$  and the accuracy of location was  $\pm 0.5\%$  to a distance of 500m. The reference position was taken to be the center of helicopter cabin.

## Figure 5.2.B

### **Japanese Video Tracker Instrumentation**



#### **5.2.6.d Cockpit Data Documentation**

Helicopter instrument performance documentation was gathered during each event using a video camera inside the helicopter to record the cockpit instruments and a calibrated watch.

#### **5.2.6.e Meteorological Data Measurement Systems**

Wind speed, wind direction, temperature and relative humidity were measured at a height of 10 m above the ground.

Temperature and relative humidity data were measured from the helicopter while it maintained level flight.

Upper air wind speed and wind direction data, from 100m to 300m AGL, were measured by sondes. The wind speed/direction instrumentation (type PR550TC) was manufactured by Ogasawara Instruments.

#### **5.2.6.f Acoustical Measurement Instrumentation**

The Japanese used RION Precision Integrating Sound Level Meters (PISLM) (types NA-60/61 and NL-11) and Kudelski NAGRA IV SJ tape recorders. With both 1/2 inch diameter "free field type" condenser microphones were used. The Japanese were obliged to use the "free field type" microphones because "pressure type" microphones were not available in Japan. As a result, the microphone type and their setting angles deviated from Annex 16 requirements.

In regards to this deviation, the Japanese sent the Program Coordinator one of the RION systems, with "free field" microphone, to examine along with background technical information.

The data concerning the RION system was examined by the Program Coordinator and the system was subsequently tested along with two GenRad PISLMs with "pressure type" microphones.

Concerning normal versus grazing response microphone settings, the examination showed that at frequencies below 100 Hz there is virtually no difference in response of the RION NA-60 system regardless of the acoustical incidence angle. For incidence angles  $\pm 45$  degrees to normal the examination showed the correction factor remains zero for frequencies below 4000 Hz. At 90 and 270 degrees there may be a small correction (less than 1 dB) in the 3150 Hz region which should be considered for the duration adjustment.

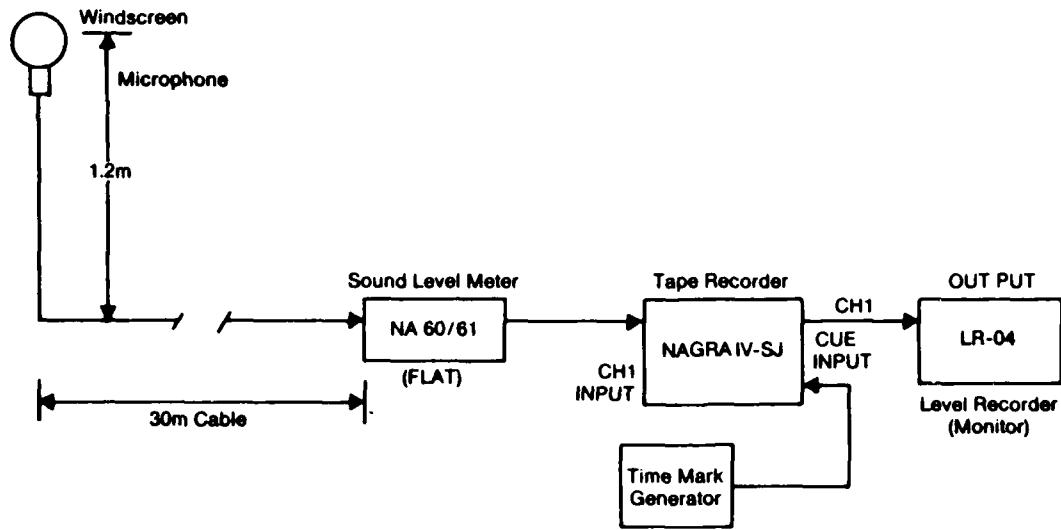
The examination further showed that considering microphone directional response characteristics, the dominant SPL Bands in the Bell 206L-1 (L-3) helicopter acoustical spectrum, and the angle of incidence for the acoustical maximum, additional corrections are not necessary to compensate for differences between the microphone used and microphones specified in Paragraph 3.2, Appendix 4, of ICAO Annex 16, Volume 1.

All of the acoustical measurement systems were calibrated by recording the standard noise produced by a pistonphone (250 Hz, 114 dB) for 30 seconds. This procedure was performed before the first flight and after the last flight for each test day.

The Japanese noise measurement instrumentation is shown in Figure 5.2.C.

## Figure 5.2.C

### ***Japanese Noise Measurement/Recording System Instrumentation***



#### 5.2.7 Noise Data Reduction

Reduction and correction of the recorded noise data was made in accordance with Annex 16 (as amended at CAN/7) and the "HNMRP Mid-Program Review-Advanced Phase Protocol" document.

### 5.2.8 Final Data Summary

The data which appears in Table 5.2.C, the Japanese "Final Corrected Data Summary," was derived from the Japanese May 1986 Participant Submittal. The only exception being the static data, which came from the Japanese September 1985 Report.

The three-microphone average for PNLT<sub>m</sub> approach, takeoff, and level flyover was calculated by the program coordinator's staff using individual event data reported in the May 1986 submittal. Delta 3 corrections were applied by the program coordinator staff to PNLT<sub>m</sub> level flyover data using individual event data reported with the May 1986 EPNL data tables.

**Table 5.2.C**

| JAPAN FINAL CORRECTED DATA   |         |        |       |       |       |       |                    |        |       |       |       |      |      |
|------------------------------|---------|--------|-------|-------|-------|-------|--------------------|--------|-------|-------|-------|------|------|
| APPROACH                     | PILOT 1 |        |       |       |       |       | PILOT 2            |        |       |       |       |      |      |
|                              | LEFT    | CENTER | RIGHT | ZMIC  | STD.  | DEV.  | LEFT               | CENTER | RIGHT | ZMIC  | STD.  | DEV. |      |
| <b>APPROACH</b>              |         |        |       |       |       |       |                    |        |       |       |       |      |      |
| EPNL                         | 89.11   | 87.56  | 90.74 | 81.21 | 0.80  | 0.50  | EPNL               | 89.70  | 83.70 | 91.56 | 91.80 | 1.80 | 0.50 |
| PNLT <sub>m</sub>            | 88.50   | 94.91  | 90.00 | 91.11 | 0.36  | 0.26  | PNLT <sub>m</sub>  | 88.00  | 95.40 | 91.20 | 91.55 | 0.84 | 0.39 |
| ALA                          | NA      | NA     | NA    | NA    | NA    | NA    | ALA                | NA     | NA    | NA    | NA    | NA   | NA   |
| SEL                          | NA      | NA     | NA    | NA    | NA    | NA    | SEL                | NA     | NA    | NA    | NA    | NA   | NA   |
| <b>LEVEL FLYOVER P1-1</b>    |         |        |       |       |       |       |                    |        |       |       |       |      |      |
| EPNL                         | 89.10   | 89.10  | 88.40 | 89.20 | 0.40  | 0.50  | EPNL               | 89.40  | 86.40 | 87.90 | 88.90 | 0.50 | 0.70 |
| PNLT <sub>m</sub>            | 91.04   | 91.44  | 89.73 | 90.42 | 0.14  | 0.16  | PNLT <sub>m</sub>  | 91.92  | 91.87 | 92.01 | 90.93 | 0.38 | 0.44 |
| ALA                          | NA      | NA     | NA    | NA    | NA    | NA    | ALA                | NA     | NA    | NA    | NA    | NA   | NA   |
| SEL                          | NA      | NA     | NA    | NA    | NA    | NA    | SEL                | NA     | NA    | NA    | NA    | NA   | NA   |
| <b>LEVEL FLYOVER P1-2</b>    |         |        |       |       |       |       |                    |        |       |       |       |      |      |
| EPNL                         | 90.50   | 83.20  | 86.81 | 88.60 | 1.40  | 0.70  | EPNL               | 91.50  | 85.10 | 87.70 | 89.40 | 0.40 | 0.50 |
| PNLT <sub>m</sub>            | 91.33   | 90.99  | 87.53 | 89.92 | 0.31  | 0.52  | PNLT <sub>m</sub>  | 91.87  | 91.50 | 88.35 | 90.57 | 0.16 | 0.19 |
| ALA                          | NA      | NA     | NA    | NA    | NA    | NA    | ALA                | NA     | NA    | NA    | NA    | NA   | NA   |
| SEL                          | NA      | NA     | NA    | NA    | NA    | NA    | SEL                | NA     | NA    | NA    | NA    | NA   | NA   |
| <b>TAKEOFF</b>               |         |        |       |       |       |       |                    |        |       |       |       |      |      |
| EPNL                         | 88.50   | 88.90  | 88.70 | 88.90 | 0.30  | 0.20  | EPNL               | 89.10  | 90.00 | 88.70 | 88.80 | 0.50 | 0.30 |
| PNLT <sub>m</sub>            | 89.30   | 89.70  | 88.70 | 89.20 | 0.22  | 0.20  | PNLT <sub>m</sub>  | 89.70  | 91.40 | 89.30 | 89.80 | 0.56 | 0.35 |
| ALA                          | NA      | NA     | NA    | NA    | NA    | NA    | ALA                | NA     | NA    | NA    | NA    | NA   | NA   |
| SEL                          | NA      | NA     | NA    | NA    | NA    | NA    | SEL                | NA     | NA    | NA    | NA    | NA   | NA   |
| <b>DURATION P</b>            |         |        |       |       |       |       |                    |        |       |       |       |      |      |
| DURATION A                   | NA      |        |       |       |       |       | DURATION P         | NA     |       |       |       |      |      |
| MAX NOY BANDS                | NA      |        |       |       |       |       | DURATION A         | NA     |       |       |       |      |      |
| <b>TONE CORRECTION VALUE</b> |         |        |       |       |       |       |                    |        |       |       |       |      |      |
| APPROACH                     | 0.80    | 0.65   | 0.73  |       |       |       | APPROACH           | 1.11   | 1.75  | 1.11  |       |      |      |
| LEVEL FLYOVER P1-1           | 1.75    | 1.28   | 1.27  |       |       |       | LEVEL FLYOVER P1-1 | 1.52   | 1.64  | 0.75  |       |      |      |
| LEVEL FLYOVER P1-2           | 1.72    | 1.27   | 1.09  |       |       |       | LEVEL FLYOVER P2-2 | 1.28   | 1.47  | 1.29  |       |      |      |
| TAKEOFF                      | 2.41    | 2.10   | 2.41  |       |       |       | TAXEOF             | 2.27   | 2.11  | 2.26  |       |      |      |
| <b>TONE CORRECTION BAND</b>  |         |        |       |       |       |       |                    |        |       |       |       |      |      |
| APPROACH                     | 24      | 25     | 26    |       |       |       | APPROACH           | 27     | 25    | 27    |       |      |      |
| LEVEL FLYOVER P1-1           | 23      | 23     | 22    |       |       |       | LEVEL FLYOVER P2-1 | 20     | 23    | 22    |       |      |      |
| LEVEL FLYOVER P1-2           | 26      | 23     | 22    |       |       |       | LEVEL FLYOVER P2-2 | 20     | 23    | 22    |       |      |      |
| TAKEOFF                      | 22      | 22     | 22    |       |       |       | TAKEOFF            | 22     | 22    | 22    |       |      |      |
| <b>STATIC FLIGHT IDLE</b>    |         |        |       |       |       |       |                    |        |       |       |       |      |      |
| 0                            | 45      | 90     | 135   | 180   | 225   | 270   | 315                |        |       |       |       |      |      |
| HARD                         | 71.70   | 77.80  | 77.91 | 77.30 | 73.90 | 75.20 | 75.00              | 75.50  |       |       |       |      |      |
| SOFT                         | 65.10   | 65.60  | 65.80 | 70.20 | 62.70 | 77.50 | 77.70              | 69.30  | 38    |       |       |      |      |

### 5.3 French - Italian Test Program

The French - Italian test program was conducted on October 16th and 17th of 1984 at la Fare-les-Oliviers aerodrome 40 Km northwest of Marignane, France. The primary measurement teams participating in the program were Service Technique de la Navigation Aerienne (STNA) and Aerospatiale from France, and Costruzioni Aeronautiche G. Agusta from Italy. The US also deployed one microphone system at the centerline-center location.

#### 5.3.1 Weather

For the certification events the temperature ranged from 17 to 18 degrees Celsius, while the relative humidity ranged from 68 to 78.5 percent. For some events, there was some difficulty with the wind exceeding the test plan proposed limitations.

#### 5.3.2 Operations

Table 5.3.A is a list of the operations conducted during the French-Italian test program.

**Table 5.3.A**

|                                   |                          |
|-----------------------------------|--------------------------|
| ICAO Flyover 150m, 0.9Vh (105kts) | Approach 12 degrees      |
| Flyover 150m, 0.8Vh (94kts)       | Approach 9 degrees       |
| Flyover 150m, 0.7Vh (82.6kts)     | ICAO Approach 6 degrees  |
| Flyover 150m, Vh (118kts)         | Approach 6 degrees Vy-20 |
| Flyover 150m, Vy (57kts)          | Approach 6 degrees Vy+20 |
| Flyover 250m, 0.9 Vh (105kts)     | Static Flight Idle       |
| ICAO Takeoff 500m                 | Takeoff 600m             |

#### 5.3.3 Pilot

Flight test operations were performed by a single test pilot.

#### 5.3.4 Test Helicopter

The test helicopter was a Bell 206L-1 leased from la Societe Heli-Air-Monaco (registration number 3AM SX).

#### 5.3.5 Test Site Array

The test site array varied in number and location of sites depending on the operation conducted. Figures 5.3.A, 5.3.B, and 5.3.C depict the test site arrays for the takeoff, level flyover and 6 degree approach operations, as presented in the Aerospatiale submittals. Throughout the program each of the primary measurement teams operated measurement systems at the noise certification sites.

Figure 5.3.A

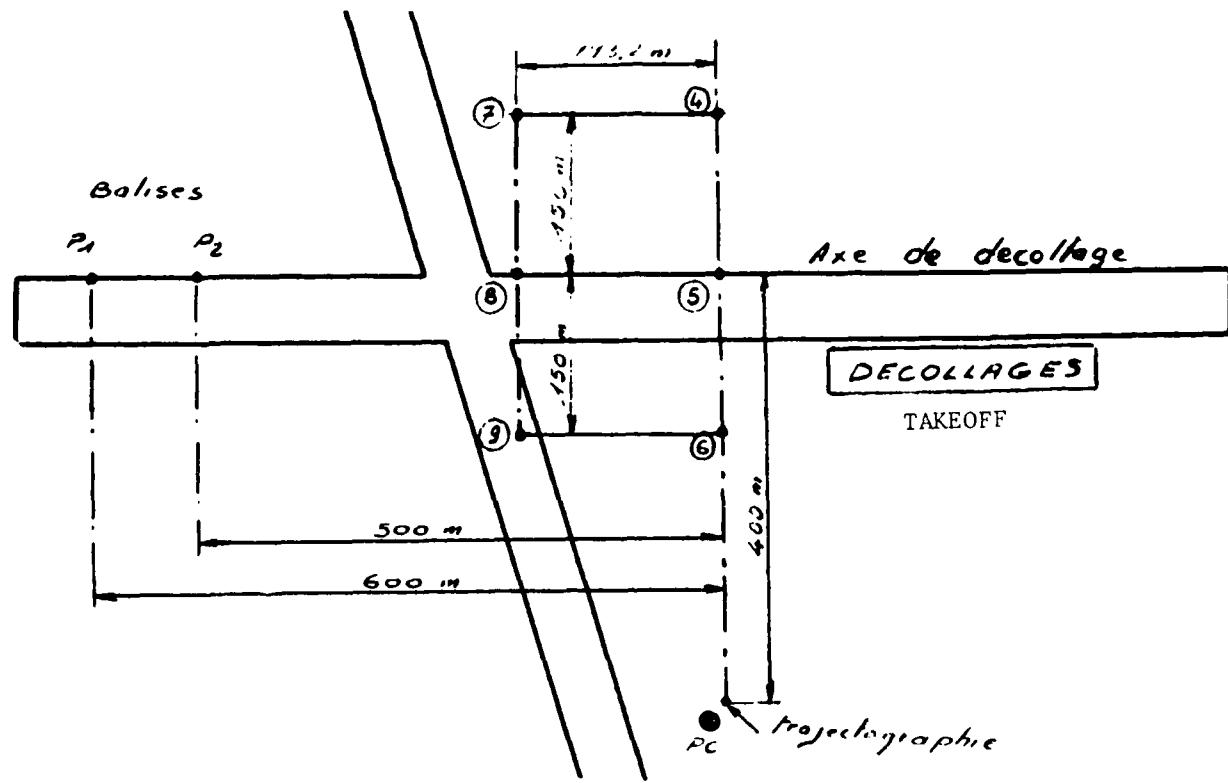
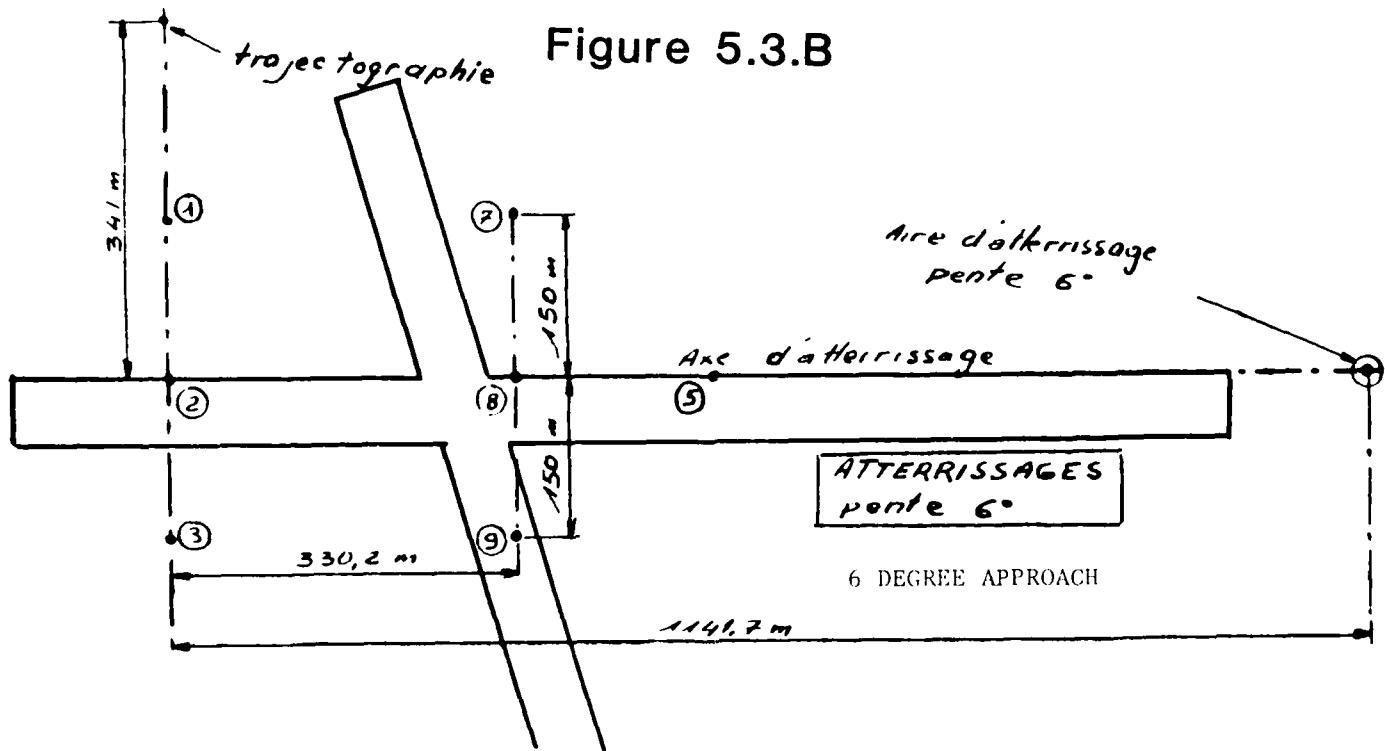
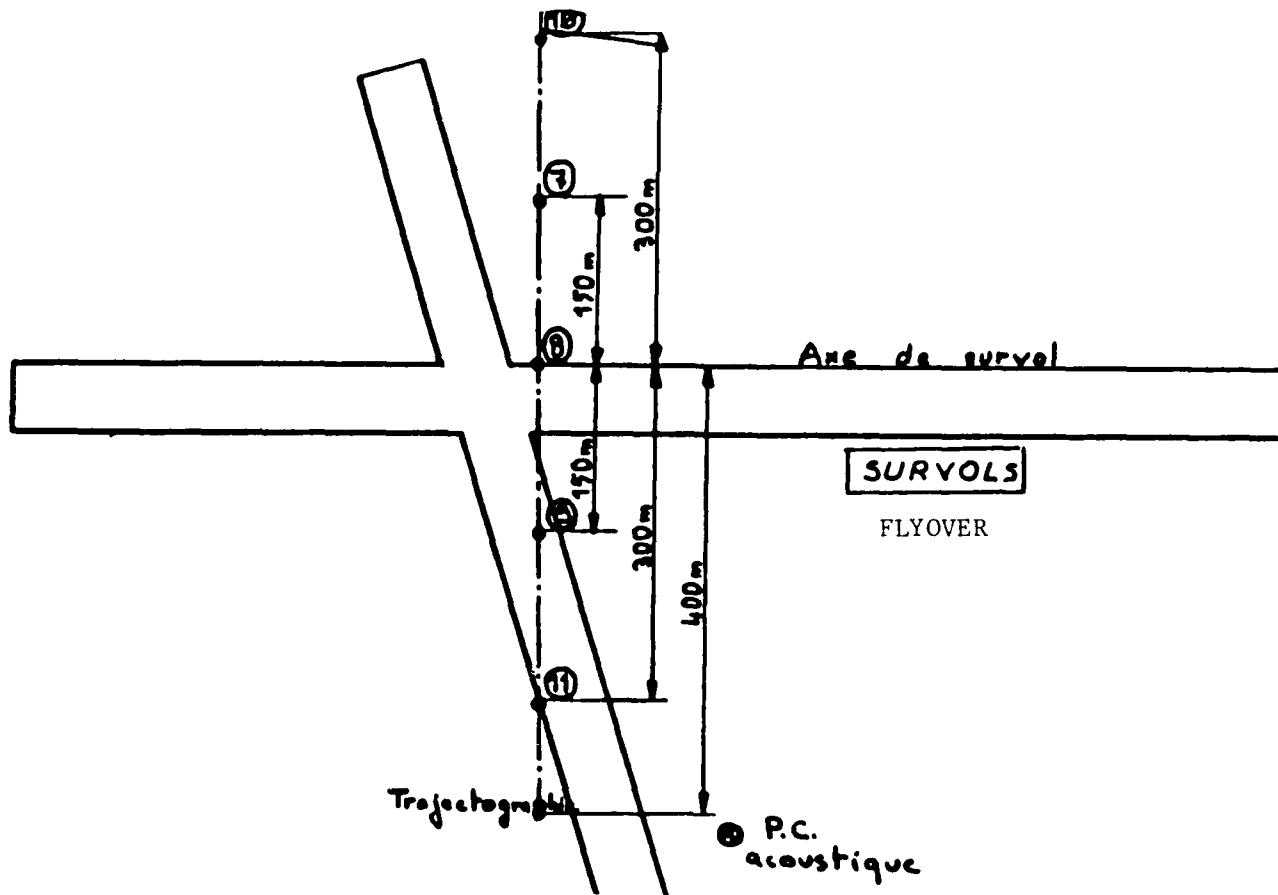


Figure 5.3.B



**Figure 5.3.C**



The ground surface of the test site area was composed of sparse grass on a clay base, which provided a very flat and homogeneous surface.

### 5.3.6 Joint Program Features

#### 5.3.6.a Cockpit Data Documentation

Helicopter performance characteristics were documented during the French-Italian test by use of a cockpit videotape system similar to those used in other HNMRF flight test programs.

#### 5.3.6.b Tracking System

Tracking data was acquired during the French-Italian test by STNA using a time-code-synchronized camera system composed of three cameras. The first camera was positioned at the centerline-center site to give altitude (within 3 meters). The second camera, located at the far end of flight path, monitored deviation from the reference flight track by the operator shooting the picture when the aircraft was orthogonal to the centerline-center site. The third camera, essentially a photo-theodolite, was positioned on the sideline and provided helicopter azimuth and elevation.

### 5.3.6.c Meteorological Data Measurement Systems

During the French-Italian flight test program a 10 meter meteorological tower was used to measure: temperature, relative humidity, wind speed and wind direction.

### 5.3.6.d Approach Guidance System

A theodolite system was used during the tests for approach guidance.

## 5.3.7 Italian Test Team

Although the Italian Costruzioni Aeronautiche G. Agusta team was one of the primary independent measurement teams, they had a series of unfortunate equipment failures which resulted in the loss of their independently acquired noise data. As such, Italian data does not appear in the analyses presented in this report. They did, however, analyze a copy of the Aerospatiale noise tapes. A comparison of the Aerospatiale and Agusta data reduction results would be very interesting, providing insight into the data reduction and processing differences between the Aerospatiale and Agusta laboratories.

## 5.3.8 Aerospatiale Test Team

The Aerospatiale team, while performing all of the HNMRP requirements, included a variety of different enhancements in their test program. First of all, they deployed several measurement systems where two separate microphones fed data into a single Nagra recorder. Secondly, they deployed an additional set of measurement sites (a centerline and two sideline sites) for the takeoff and approach operations--see Figures 5.3.A and 5.3.B. Thirdly, they analyzed their data by both the ICAO Annex 16 procedures and an alternative method. This report presents only the data requested by the HNMRP. Examination of the Aerospatiale enhancement exercises would be a very worthwhile future work item.

### 5.3.8.a Aerospatiale Final Summary Data

Table 5.3.A is a presentation of the Aerospatiale final summary data. This data was derived from a facsimile communication with Aerospatiale dated March 24, 1987 and from the April 1986 submittals.

### 5.3.8.b Aerospatiale Program Notes

The following are notes which the Aerospatiale requested be included in the final HNMRP report.

The French-Italian ICAO 6 degree approach flights were performed under wind conditions which exceeded the 5 kts maximum specified by the HNMRP. It is the feeling of Aerospatiale that, "These weather conditions considerably disturbed the paths followed and subsequently the pulse noise generation, which is the

characteristic feature of this phase of flight....If these approach phase measurements had been made for a helicopter certification instead of an acoustic repeatability program study, they would not have been presented by Aerospatiale."

They further went on to state, "We believe that the approach measurement results obtained by Aerospatiale in 'outside standards' conditions for a helicopter displaying particular characteristics in this flight phase cannot be integrally included in the HNMRP comparisons without introducing in the statistic study a variance that might alter the repeatability conclusions. So in order to prevent the effects of these variations and to provide measurement results representative of the ICAO reference conditions: 6 degree slope, selection was made among all the available measurement points. Hence: flights 100-101-103, microphones 1/2/3."

Concerning the Aerospatiale submittals: The April 1986 data submittals are a complete presentation of as-measured data adjusted for ambient noise levels. The "Summary Report" presents corrected data with an "average correction" method. Aerospatiale Annex 16, Chapter 8, Appendix 4 corrected results are unpublished, but were transmitted to the HNMRP Program Coordinator in a March 24, 1987 telex. For flyover and takeoff the 3-microphone average noise levels are the same for the Annex 16 correction and for the simplified method.

### 5.3.9 STNA Test Team

The STNA team deployed Nagra measurement systems at the certification test sites. Recorded noise data reduction was made in compliance with the procedures detailed in the HNMRP reference documentation.

Table 5.3.B is a presentation of the STNA final summary data as confirmed by a November 26, 1986 telex.

### 5.3.10 Additional Information

The information used to prepare this chapter was derived from the STNA, Aerospatiale, and Agusta participant submittals, as well as from an audio tape made by the HNMRP Program Coordinator during the actual test.

**Table 5.3.B**

| FRANCE AEROSPACEABLE FINAL CORRECTED DATA |       |        |       |       |      |        |               |          |          |          |       |      |      |
|---|-------|--------|-------|-------|------|--------|---------------|----------|----------|----------|-------|------|------|
|   | STS   |        |       |       |      |        |               |          |          |          |       |      |      |
|   | LEFT  | CENTER | RIGHT | CMIC  | DEV  | 90° CI |               |          |          |          |       |      |      |
| <b>APPROACH</b>                           |       |        |       |       |      |        |               |          |          |          |       |      |      |
| EPNL                                      | 86.10 | 92.30  | 89.40 | 89.00 | 0.84 | 1.40   | EPNL          | 85.10    | 91.40    | 88.70    | 88.70 | 1.30 | 1.40 |
| PNLT™                                     | 86.60 | 94.70  | 91.10 | 91.50 | 1.22 | 2.05   | PNLT™         | 85.70    | 92.40    | 89.70    | 89.47 | 1.31 | 1.31 |
| ALA                                       | NA    | NA     | NA    | NA    | NA   | NA     | ALA           | 71.50    | 75.90    | 74.5     | 74.10 | 1.12 | 1.51 |
| SEL                                       | NA    | NA     | NA    | NA    | NA   | NA     | SEL           | 81.70    | 88.20    | 86.7     | 86.40 | 1.61 | 1.51 |
| <b>LEVEL FLYOVERS</b>                     |       |        |       |       |      |        |               |          |          |          |       |      |      |
| EPNL                                      | 87.90 | 89.40  | 86.80 | 87.70 | 0.36 | 0.40   | EPNL          | 85.70    | 87.50    | 87.9     | 85.80 | 1.41 | 0.50 |
| PNLT™                                     | 90.70 | 91.20  | 89.00 | 90.70 | 0.64 | 0.75   | PNLT™         | 86.20    | 91.10    | 86.80    | 89.10 | 1.31 | 1.26 |
| ALA                                       | NA    | NA     | NA    | NA    | NA   | NA     | ALA           | 73.70    | 77.00    | 73.30    | 74.57 | 1.53 | 1.53 |
| SEL                                       | NA    | NA     | NA    | NA    | NA   | NA     | SEL           | 81.70    | 87.80    | 81.80    | 81.97 | 1.7  | 1.7  |
| <b>TAKEOFF</b>                            |       |        |       |       |      |        |               |          |          |          |       |      |      |
| EPNL                                      | 85.70 | 86.40  | 87.40 | 87.20 | 0.64 | 0.57   | EPNL          | 84.70    | 87.70    | 94.50    | 85.50 | 1.40 | 0.70 |
| PNLT™                                     | 85.50 | 88.90  | 88.80 | 88.00 | 0.86 | 0.71   | PNLT™         | 85.70    | 89.00    | 85.80    | 86.50 | 1.51 | 0.46 |
| ALA                                       | NA    | NA     | NA    | NA    | NA   | NA     | ALA           | 71.50    | 74.00    | 71.40    | 71.87 | 1.71 | 1.21 |
| SEL                                       | NA    | NA     | NA    | NA    | NA   | NA     | SEL           | 82.10    | 85.50    | 81.70    | 82.00 | 1.79 | 0.20 |
| <b>DURATION F</b>                         |       |        |       |       |      |        |               |          |          |          |       |      |      |
| APPROACH                                  | 15.30 | 17.80  | 20.20 |       |      |        | APPROACH      | 28.70    | 19.10    | 21.30    |       |      |      |
| LEVEL FLYOVER                             | 15.10 | 12.90  | 16.90 |       |      |        | LEVEL FLYOVER | 10.90    | 17.10    | 16.10    |       |      |      |
| TAKEOFF                                   | 25.80 | 16.10  | 21.50 |       |      |        | TAKEOFF       | 22.10    | 11.60    | 18.10    |       |      |      |
| <b>DURATION A</b>                         |       |        |       |       |      |        |               |          |          |          |       |      |      |
| APPROACH                                  | 27.50 | 19.00  | 23.30 |       |      |        | APPROACH      | 29.10    | 19.60    | 21.40    |       |      |      |
| LEVEL FLYOVER                             | 16.40 | 11.00  | 15.90 |       |      |        | LEVEL FLYOVER | 15.00    | 11.80    | 12.00    |       |      |      |
| TAKEOFF                                   | 29.40 | 20.80  | 26.10 |       |      |        | TAKEOFF       | 23.70    | 14.30    | 21.00    |       |      |      |
| <b>TONE CORRECTION VALUE</b>              |       |        |       |       |      |        |               |          |          |          |       |      |      |
| APPROACH                                  | 1.30  | 1.00   | 1.00  |       |      |        | APPROACH      | 1.20     | 1.00     | 1.00     |       |      |      |
| LEVEL FLYOVER                             | 2.10  | 1.30   | 1.40  |       |      |        | LEVEL FLYOVER | 2.40     | 1.70     | 1.80     |       |      |      |
| TAKEOFF                                   | 2.50  | 2.20   | 2.50  |       |      |        | TAKEOFF       | 2.40     | 2.40     | 2.50     |       |      |      |
| <b>TONE CORRECTION BAND</b>               |       |        |       |       |      |        |               |          |          |          |       |      |      |
| APPROACH                                  | 27.7  | 25     | 23    |       |      |        | APPROACH      | 27       | 27       | 25       |       |      |      |
| LEVEL FLYOVER                             | 22    | 22     | 22    |       |      |        | LEVEL FLYOVER | 22       | 22       | 22       |       |      |      |
| TAKEOFF                                   | 22    | 22     | 22    |       |      |        | TAKEOFF       | 22       | 22       | 22       |       |      |      |
| MAX NOY BAND                              | NA    |        |       |       |      |        | MAX NOY BAND  |          |          |          |       |      |      |
| STATIC                                    |       |        |       |       |      |        | APPROACH      | 24,25,25 | 26,25,25 | 25,25,27 |       |      |      |
| HARD                                      |       |        |       |       |      |        | LEVEL FLYOVER | 23,27,29 | 25,25,25 | 24,25,27 |       |      |      |
| 0   | 45    | 90     | 135   | 180   | 225  | 270    | TAKEOFF       | 21,22,21 | 27,25,25 | 25,27,27 |       |      |      |
| 70.9                                      | 71.4  | 71.9   | 69.7  | 67.9  | 68.2 | 70.0   |               |          |          |          |       |      |      |
|   |       |        |       |       |      |        |               |          |          |          |       |      |      |

\*FOR STATIC 270 DEGREE ANGLE THE NUMBERS SHOWN ARE  
AVERAGES OF TWO 270 DEGREE EVENTS

**Table 5.3.C**

| FRANCE ST1A FINAL CORRECTED DATA |       |        |       |       |      |        |               |          |          |          |       |      |      |
|----------------------------------|-------|--------|-------|-------|------|--------|---------------|----------|----------|----------|-------|------|------|
|                                  | STS   |        |       |       |      |        |               |          |          |          |       |      |      |
|                                  | LEFT  | CENTER | RIGHT | CMIC  | DEV  | 90° CI |               |          |          |          |       |      |      |
| <b>APPROACH</b>                  |       |        |       |       |      |        |               |          |          |          |       |      |      |
| EPNL                             | 85.10 | 91.40  | 88.70 | 88.70 | 1.30 | 1.40   | EPNL          | 85.10    | 91.40    | 88.70    | 88.70 | 1.30 | 1.40 |
| PNLT™                            | 85.70 | 92.40  | 89.70 | 89.47 | 1.31 | 1.31   | PNLT™         | 85.70    | 92.40    | 89.70    | 89.47 | 1.31 | 1.31 |
| ALA                              | 71.50 | 75.90  | 74.5  | 74.10 | 1.12 | 1.51   | ALA           | 71.50    | 75.90    | 74.5     | 74.10 | 1.12 | 1.51 |
| SEL                              | 81.70 | 88.20  | 86.7  | 86.40 | 1.61 | 1.51   | SEL           | 81.70    | 88.20    | 86.7     | 86.40 | 1.61 | 1.51 |
| <b>LEVEL FLYOVER</b>             |       |        |       |       |      |        |               |          |          |          |       |      |      |
| EPNL                             | 85.70 | 87.50  | 87.9  | 85.80 | 1.41 | 0.50   | EPNL          | 85.70    | 87.50    | 87.9     | 85.80 | 1.41 | 0.50 |
| PNLT™                            | 86.20 | 91.10  | 86.80 | 89.10 | 1.31 | 1.26   | PNLT™         | 86.20    | 91.10    | 86.80    | 89.10 | 1.31 | 1.26 |
| ALA                              | 73.70 | 77.00  | 73.30 | 74.57 | 1.53 | 1.53   | ALA           | 73.70    | 77.00    | 73.30    | 74.57 | 1.53 | 1.53 |
| SEL                              | 81.70 | 87.80  | 81.80 | 81.97 | 1.7  | 1.7    | SEL           | 81.70    | 87.80    | 81.80    | 81.97 | 1.7  | 1.7  |
| <b>TAKEOFF</b>                   |       |        |       |       |      |        |               |          |          |          |       |      |      |
| EPNL                             | 84.70 | 87.70  | 94.50 | 85.50 | 1.40 | 0.70   | EPNL          | 84.70    | 87.70    | 94.50    | 85.50 | 1.40 | 0.70 |
| PNLT™                            | 85.70 | 89.00  | 85.80 | 86.50 | 1.51 | 0.46   | PNLT™         | 85.70    | 89.00    | 85.80    | 86.50 | 1.51 | 0.46 |
| ALA                              | 71.50 | 74.00  | 71.40 | 71.87 | 1.71 | 1.21   | ALA           | 71.50    | 74.00    | 71.40    | 71.87 | 1.71 | 1.21 |
| SEL                              | 82.10 | 85.50  | 81.70 | 82.00 | 1.79 | 0.20   | SEL           | 82.10    | 85.50    | 81.70    | 82.00 | 1.79 | 0.20 |
| <b>DURATION F</b>                |       |        |       |       |      |        |               |          |          |          |       |      |      |
| APPROACH                         | 28.70 | 19.10  | 21.30 |       |      |        | APPROACH      | 28.70    | 19.10    | 21.30    |       |      |      |
| LEVEL FLYOVER                    | 10.90 | 17.10  | 16.10 |       |      |        | LEVEL FLYOVER | 10.90    | 17.10    | 16.10    |       |      |      |
| TAKEOFF                          | 22.10 | 11.60  | 18.10 |       |      |        | TAKEOFF       | 22.10    | 11.60    | 18.10    |       |      |      |
| <b>DURATION A</b>                |       |        |       |       |      |        |               |          |          |          |       |      |      |
| APPROACH                         | 29.10 | 19.60  | 21.40 |       |      |        | APPROACH      | 29.10    | 19.60    | 21.40    |       |      |      |
| LEVEL FLYOVER                    | 15.00 | 11.80  | 12.00 |       |      |        | LEVEL FLYOVER | 15.00    | 11.80    | 12.00    |       |      |      |
| TAKEOFF                          | 23.70 | 14.30  | 21.00 |       |      |        | TAKEOFF       | 23.70    | 14.30    | 21.00    |       |      |      |
| <b>TONE CORRECTION VALUE</b>     |       |        |       |       |      |        |               |          |          |          |       |      |      |
| APPROACH                         | 1.20  | 1.00   | 1.00  |       |      |        | APPROACH      | 1.20     | 1.00     | 1.00     |       |      |      |
| LEVEL FLYOVER                    | 2.40  | 1.70   | 1.80  |       |      |        | LEVEL FLYOVER | 2.40     | 1.70     | 1.80     |       |      |      |
| TAKEOFF                          | 2.40  | 2.40   | 2.50  |       |      |        | TAKEOFF       | 2.40     | 2.40     | 2.50     |       |      |      |
| <b>TONE CORRECTION BAND</b>      |       |        |       |       |      |        |               |          |          |          |       |      |      |
| APPROACH                         | 27    | 27     | 25    |       |      |        | APPROACH      | 27       | 27       | 25       |       |      |      |
| LEVEL FLYOVER                    | 22    | 22     | 22    |       |      |        | LEVEL FLYOVER | 22       | 22       | 22       |       |      |      |
| TAKEOFF                          | 22    | 22     | 22    |       |      |        | TAKEOFF       | 22       | 22       | 22       |       |      |      |
| MAX NOY BAND                     | NA    |        |       |       |      |        | MAX NOY BAND  |          |          |          |       |      |      |
| STATIC                           |       |        |       |       |      |        | APPROACH      | 24,25,25 | 26,25,25 | 25,25,27 |       |      |      |
| HARD                             |       |        |       |       |      |        | LEVEL FLYOVER | 23,27,29 | 25,25,25 | 24,25,27 |       |      |      |
| 0                                | 45    | 90     | 135   | 180   | 225  | 270    | TAKEOFF       | 21,22,21 | 27,25,25 | 25,27,27 |       |      |      |
| 70.9                             | 71.4  | 71.9   | 69.7  | 67.9  | 68.2 | 70.0   |               |          |          |          |       |      |      |
|                                  |       |        |       |       |      |        |               |          |          |          |       |      |      |

## 5.4 United Kingdom - Federal Republic of Germany Test Program

This section describes the joint United Kingdom / Federal Republic of Germany (UK/FRG) noise measurement flight test program carried out between July 2nd and 6th of 1984 at the British Aerospace Dunsfold Airfield in Surrey, England.

The overall UK/FRG program coordinator was from the UK Civil Aviation Organization (CAA). UK involvement was funded by the UK Department of Trade and Industry, and measurement teams were deployed by Westland Helicopters Limited (WHL) and British Aerospace (BAe). FRG participation came from the German Aerospace Research Establishment (DFVLR). The HNMMP program-coordinator was also present during the flight tests.

### 5.4.1 Weather

The flight tests were carried out in exceptionally good weather conditions, with sunny and warm weather throughout the test period. Cross winds during the early part of the flight tests, however, often exceeded the permitted range leading to aborted test runs. As a consequence, it was necessary to shift the measuring sites to another runway location during the program.

### 5.4.2 Operations

Table 5.4.A is a list of the operations conducted during the UK/FRG flight test program. Due to time constraints, the number of "good" flight events for the elective flight operations was reduced to four. Each flight condition was repeated a sufficient number of times to ensure the required 6 (or 4) "good", i.e. valid, runs.

The UK team was unable to measure the Pilot 2 level flyover and approach operations due to equipment problems.

It should also be noted that all of the level flyover tests series were performed at an airspeed significantly lower than the target airspeed. Under the prevailing conditions, the maximum speed in level flight VH (which is equivalent to the "Never Exceed Speed" VNE for the subject helicopter) could not be flown due to turbine outlet temperature limitations. Therefore, it was quite important to apply source noise adjustments.

### 5.4.3 Pilots

The pilots flying the test operations were: Pilot 1 from the UK CAA and Pilot 2 from Air Hanson Ltd of Weybridge, Surrey, England.

### 5.4.4 Test Helicopter

The helicopter tested was a Bell 206L-1 from Air Hanson Limited of Weybridge, Surrey, England.

**Table 5.4.A**

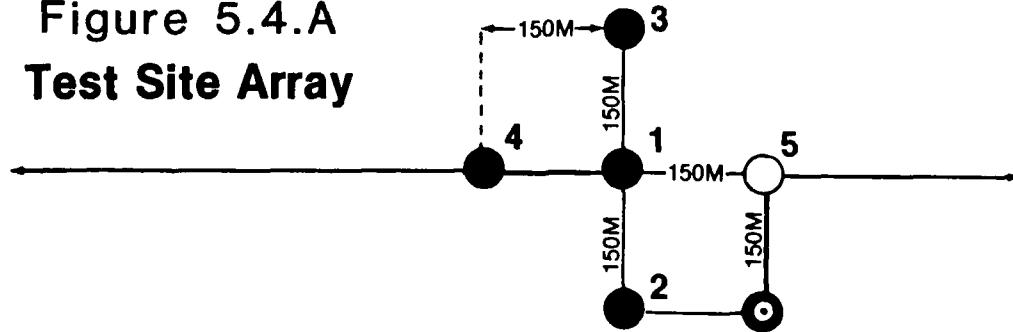
UK-FRG FLIGHT TEST PROGRAM

| ID | PILOT | OPERATION               | ID | PILOT | OPERATION               |
|----|-------|-------------------------|----|-------|-------------------------|
| A1 | 1     | TAKEOFF Vy              | C1 | 1     | 6 DEGREE APPROACH Vy    |
| A2 | 2     | TAKEOFF Vy              | C2 | 2     | 6 DEGREE APPROACH Vy    |
| B1 | 1     | FLYOVER 0.9 Vh          | J1 | 1     | 6 DEGREE APPROACH Vy+20 |
| B2 | 2     | FLYOVER 0.9 Vh          | J2 | 2     | 6 DEGREE APPROACH Vy+20 |
| F  | 1     | FLYOVER 0.7 Vh          | K1 | 1     | 6 DEGREE APPROACH Vy-17 |
| G  | 1     | FLYOVER 0.8 Vh          | K2 | 2     | 6 DEGREE APPROACH Vy-17 |
| H  | 1     | FLYOVER 0.9 Vh          |    |       |                         |
| D  | 1     | STATIC                  | P1 | 1     | BELL REC. APPROACH      |
| E  | 1     | STATIC                  | P2 | 2     | BELL REC. APPROACH      |
| L1 | 1     | 9 DEGREE APPROACH Vy    | R1 | 1     | 6 DEG. APP. NO GUIDANCE |
| L2 | 2     | 9 DEGREE APPROACH Vy    | R2 | 2     | 6 DEG. APP. NO GUIDANCE |
| M1 | 1     | 9 DEGREE APPROACH Vy+20 | N1 | 1     | 9 DEGREE APPROACH Vy-17 |
| M2 | 2     | 9 DEGREE APPROACH Vy+20 | N2 | 2     | 9 DEGREE APPROACH Vy-17 |

#### 5.4.5 Test Site Array

The British Aerospace (BAe) airfield at Dunsfold, Surrey, England was selected as the location for the field test. The airfield included one operational and two unused runways, which allowed for five possible microphone array variations. As mentioned above, due to cross winds during the early part of the flight test it was necessary to shift the test site array to avoid continued problems. The relationship of sites to one another, shown in the general site array--Figure 5.4.A, was basically held constant throughout the test. (For takeoff and approach measurements site 4 was positioned at the low altitude centerline position.)

**Figure 5.4.A**  
**Test Site Array**



- Flight Operations Acoustic Measurement Site
- Hover Point
- Static Operation Acoustic Measurement Site

Due to the number of measurement systems deployed, the layout around each acoustical measurement site (particularly the central measurement site) had to be carefully thought out such as to incorporate all of the different microphone configurations and cameras. Each microphone system was generally separated by a distance of 4 meters for the 1.2m microphones and 6 meters for the ground microphones. Care was also necessary for a proper electric cabling around each measurement site to accommodate the multi-channel FM system which was deployed by the FRG team. (This system was operated and powered from a central van and required long lengths of cables across the airfield.)

Synchronization between the different measuring teams and positions was provided by portable radios and referenced to IRIG B time standard.

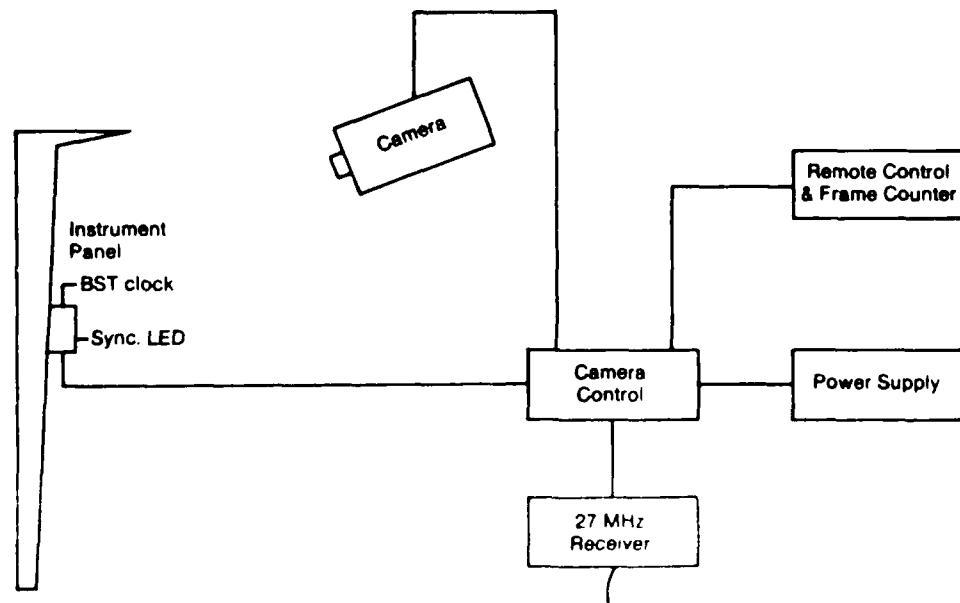
#### 5.4.6 Joint Program Features

##### 5.4.6.a Cockpit Data Documentation

A requirement introduced by the CAA, and strongly supported by the HNMPP Program Coordinator, was to record the cockpit instrument readings, at a rate of one-per-second, throughout each test flight. This requirement was fulfilled by the WHL team using a Vinten Scientific 16mm cine camera and associated equipment (operated from a 24 volt DC battery power supply). Figure 5.4.B is a schematic depiction of this system. The camera was mounted on the cockpit fire extinguisher mounting points, such that the entire instrument panel was in view. Film cassettes containing approximately 2000 frames could be fitted into the camera in situ under normal day light conditions. Each run was identified by holding a note pad, with the run number inscribed on it, in the camera field of view at the start of the run.

**Figure 5.4.B**

**UK/FRG Cockpit Instrument Recording System**



The cockpit photographs were synchronized to the acoustical measurements and tracking data using 27 MHz radio transmissions. When the ground cameras were operated they triggered a radio transmission which was picked up on the acoustical tapes and also caused a light mounted on the cockpit instrument panel to flash which was recorded by the camera.

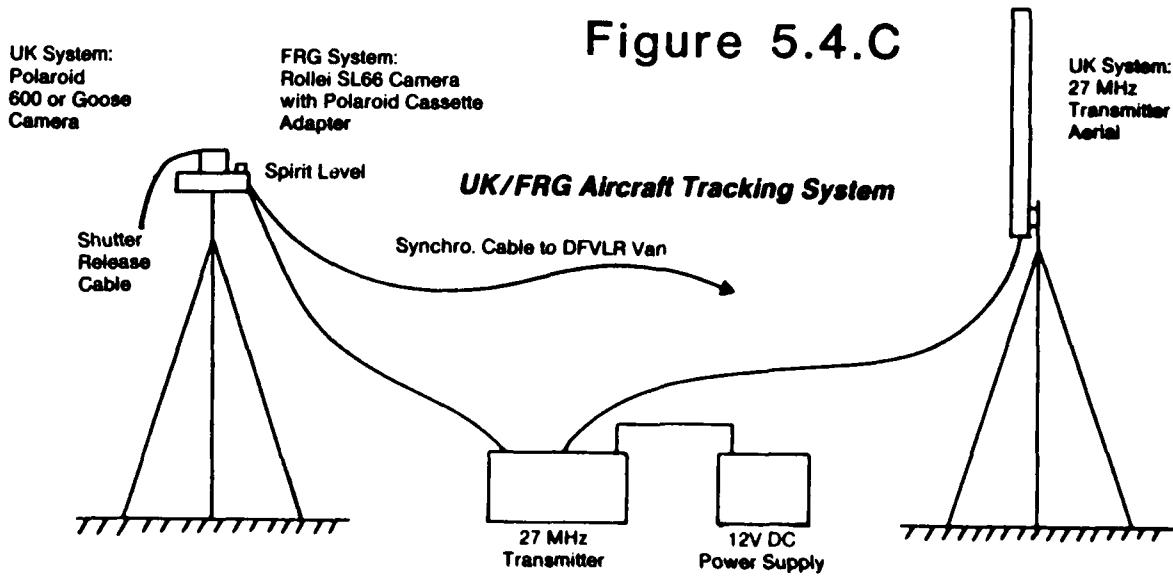
A video camera was also employed during the tests as a back-up for the cine camera. During each event, the flight observer also kept a record of the most important cockpit instrument readings. It should be noted that the cockpit IAS readings were in units of statute miles per hour (mph) instead of nautical miles per hour (kts).

#### 5.4.6.b Tracking System

Tracking data was acquired for the UK/FRG test via a sophisticated photo altitude determination system, depicted in Figure 5.4.C. The system was synchronized (as mentioned above) to the other data measurement instrumentation systems with 27 MHz radio transmissions. The photometric scaling techniques utilized were applied separately by both teams; the FRG and UK teams operated two and three cameras, respectively.

All of the five camera stations were positioned along the flight track such that the "long edge" of the photographs would be parallel to the flight track. The exact positions of the two outboard UK-WHL stations depended upon the flight track used, but the two FRG-DFVLR stations--along with the central UK-BAe station--were always at fixed positions, namely 21 m uptrack, and 200 m and 15 m downtrack, respectively. The cameras were focussed at infinity and set at maximum shutter speed (1/500 sec) with the aperture adjusted to suit ambient light conditions. During a flight event, each camera when operated triggered a synchronization impulse which was transmitted to the recording stations. A photographic print was available shortly after the photographs were taken. Aircraft altitude and lateral and longitudinal displacement from the ideal flight path could thus be determined at each camera station by photo-scaling techniques. Images were measured using either an episcopic or a travelling microscope. This unique on-site photo-scaling ability allowed timely track keeping verification.

Figure 5.4.C



Although the two teams informed one another of their results, each team used only their own results for the reduction and correction of their noise data; thus maintaining the policy of acquiring two independent sets of data.

#### 5.4.6.c Approach Guidance System

The approach guidance system used for the UK/FRG flight test was a semi-portable Precision Approach Path Indicator (PAPI) supplied and operated by the UK team. The PAPI system used is essentially a two color light projector consisting of a lamp, red filter and lens positioned so as to project a beam of light, the upper half of which is white, the lower red. The system is comprised of two units, each of which has two lamps. The units were arranged at 90 degrees to the approach path centerline ground track, approximately 5 m to either side of the approach path origin. One unit was set such that the red/white boundary was at the lower limit of the desired approach angle, the other unit at the higher limit. Thus, the approaching pilot saw one red light and one white light if he was within the required glide slope limits, two whites if he was too high or two reds if he was too low.

Each unit was mounted on a rigid 't' frame which, for the purposes of this relatively short test, was placed firmly onto a flattened ground surface. This type of installation requires frequent checking of the set angles since the stability of a grass surface is questionable. It was found during the test that one unit did in fact move significantly during a long unattended period of several hours (reasons unknown). From then on the units were checked frequently at convenient intervals during testing.

#### 5.4.7 Federal Republic of Germany Team

##### 5.4.7.a Photo Determination System Equipment

The FRG-DFVLR ground tracking system employed two identical stations, each comprised of a Rollei SL 66 camera with 150 mm focal length lens and a Polaroid cassette adapter attached to the camera, all of which was mounted on a heavy tripod. Each camera was connected, via an electric cable, to the central noise measurement station in the acoustic van, where the synchronizing trigger signals were recorded.

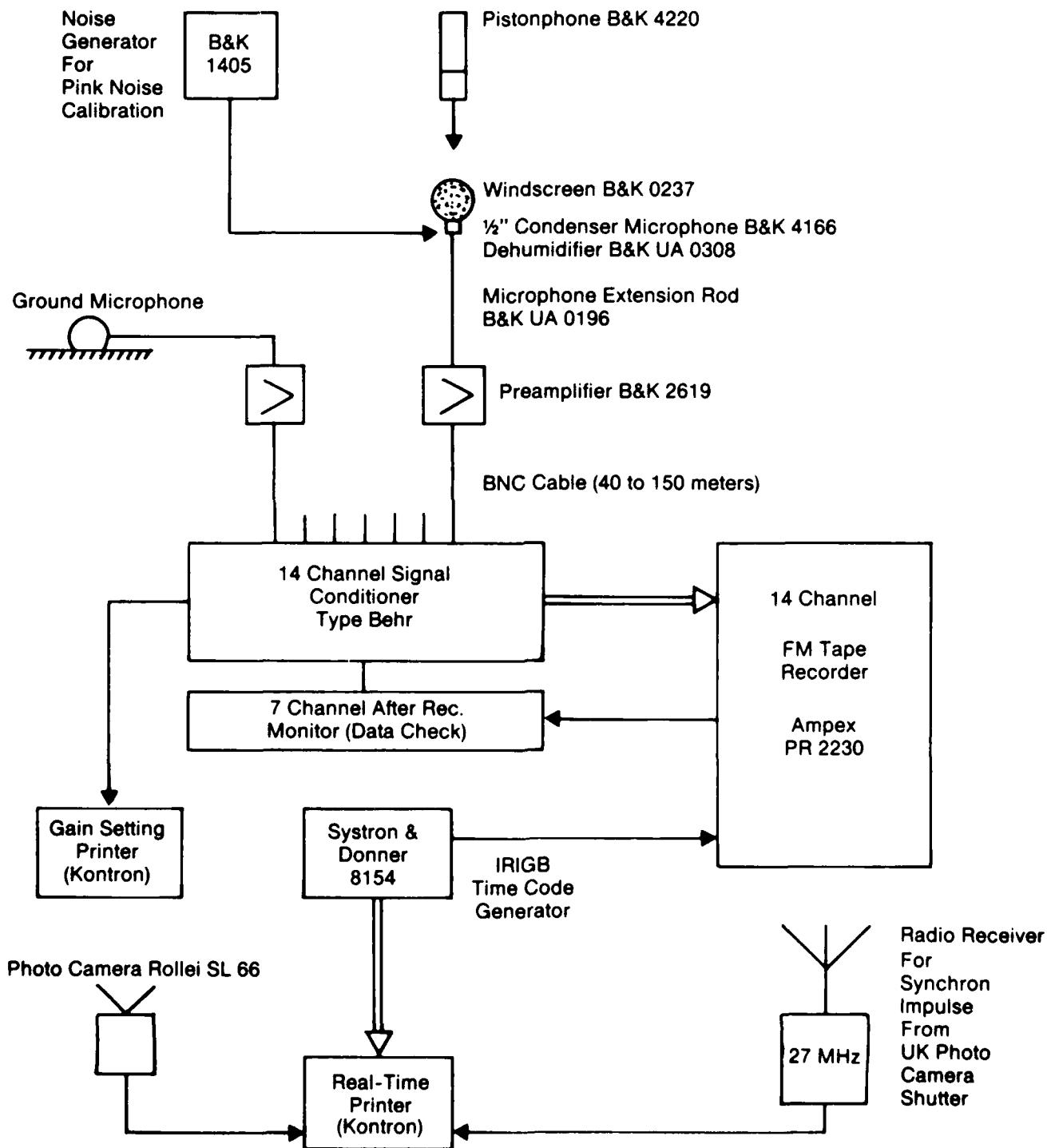
##### 5.4.7.b Acoustic Data Acquisition

During the test the FRG team employed a central noise recording station to record the noise data from each of the FRG sites. This system, located in the DFVLR Acoustic Van, is comprised of a 14-track FM magnetic tape recorder, a 14-channel signal conditioning-and-monitoring unit (with automatic gain setting printer), and an IRIG B time-code generator. Figure 5.4.D. is a schematic diagram of the FRG acoustic data acquisition instrumentation.

For flight operations, the FRG-DFVLR team deployed a total of eight microphones. The centerline-center site was equipped with two 1.2 m and one ground microphone. The two sideline sites were each equipped with a 1.2 m and a ground microphone. A 1.2 m PISLM system was also at the centerline-center

**Figure 5.4.D**

**FRG Acoustic Data Acquisition Instrumentation**

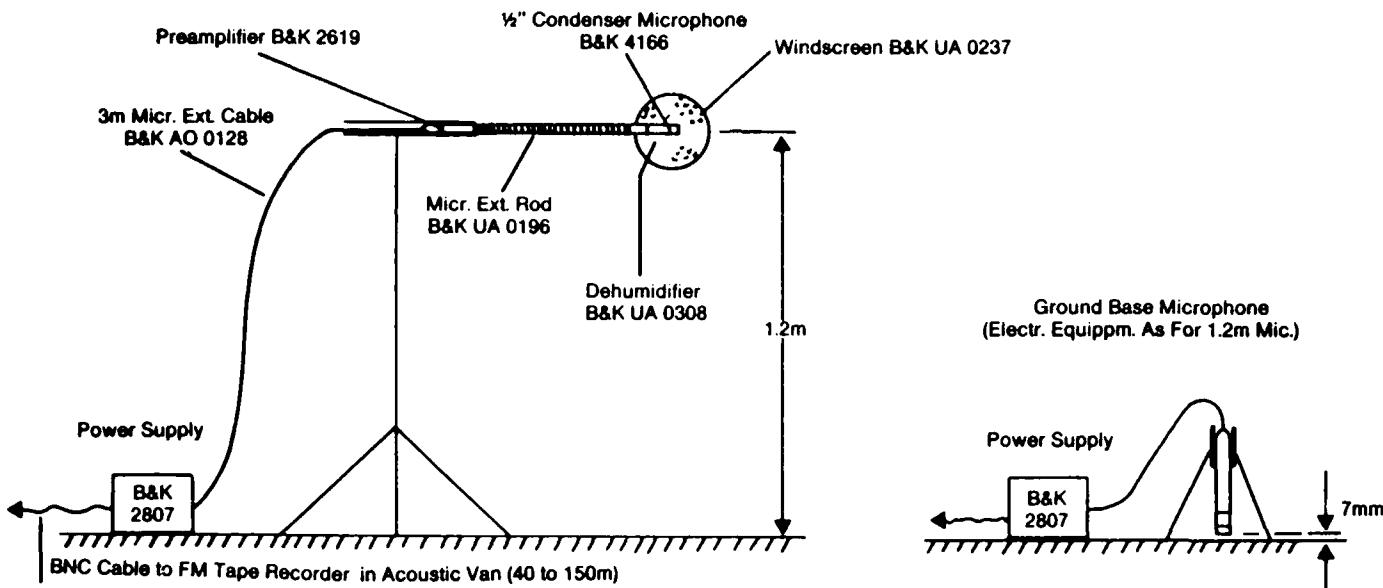


site. The final 1.2 m microphone was deployed at the additional centerline site--4. Data from each of these microphones fed into separate channels of the Ampex PR 2230 tape recorder contained in the DFVLR Acoustic Van. Figure 5.4.E depicts a typical FRG noise measurement station.

For static operations, 1.2 m recording system microphones were deployed at the 150 m soft and hard propagation path sites.

## Figure 5.4.E

### *Typical FRG Noise Measuring Station*



### 5.4.7.c      Noise Data Reduction

Processing and analysis of the acoustic recordings were performed using the DFVLR Technical Acoustics Laboratory's data analysis system. This system is controlled by a LSI 11/25 micro processor which is linked by a 16-bit parallel interface to the local DFVLR computer center's VAX 11750. The VAX in turn is linked to the DFVLR IBM 4381 main computer, allowing access to output plotter and laser printer facilities. A schematic of the system and hardware used is shown in Figure 5.4.F.

Included in the FRG report was the following foot note:

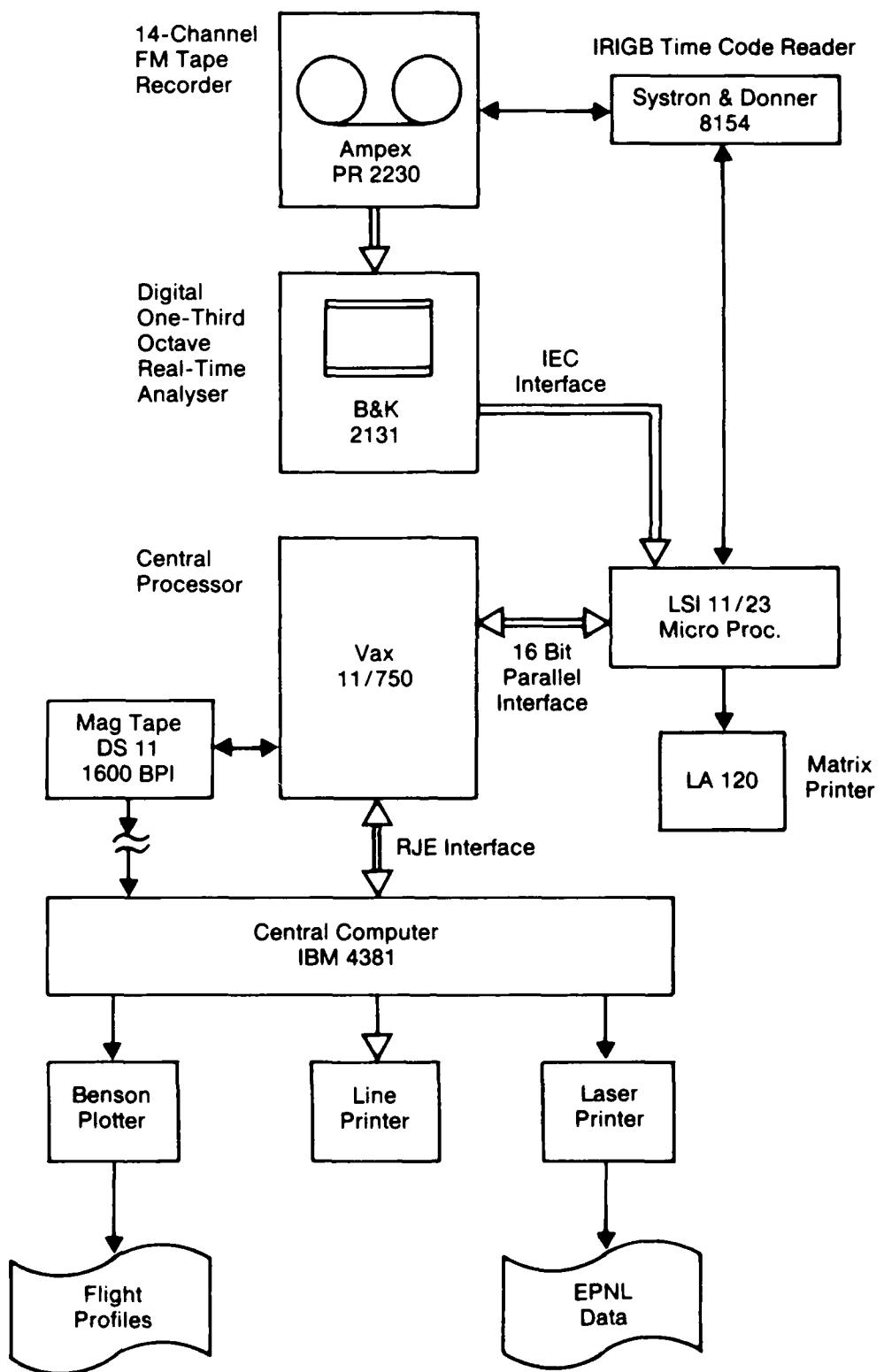
"Care should be taken when ALM and OASPLM results are compared between different laboratories. It should be noted how many one-third octave bands have been included in the calculation, since it was found that differences in level of approximately 2 dB(A) can occur for ALM and more than 6 dB for OASPLM, if all of the 42 bands of the one-third octave band analyzer instead of the recommended 24 bands are being used."

### 5.4.7.d      Final Data Summary

The data which appears in the FRG "Final Corrected Data Summary", Table 5.4.B, was derived from the FRG December 1985 Report, with the exception of the static data and corrections to the approach data which came from a September 1986 Submittal.

**Figure 5.4.F**

**FRG Data Analysis And Processing System**



# Table 5.4.B

FINAL CORRECTED DATA FEDERAL REPUBLIC OF GERMANY

|   | PILOT 1  |        |          |       |          |       | PILOT 2 |                   |          |       |          |       |          |        |
|---|----------|--------|----------|-------|----------|-------|---------|-------------------|----------|-------|----------|-------|----------|--------|
|   | LEFT     | CENTER | RIGHT    | 3MIC  | STD.     | DEV.  | 90% CI  | LEFT              | CENTER   | RIGHT | 3MIC     | STD.  | DEV.     | 90% CI |
| <b>APPROACH</b>   |          |        |          |       |          |       |         |                   |          |       |          |       |          |        |
| EPNL  | 86.90    | 92.30  | 89.10    | 89.50 | 0.60     | 0.40  |         | EPNL              | 86.30    | 92.60 | 89.90    | 89.60 | 0.50     | 0.40   |
| PNLT <sub>m</sub>   | 85.30    | 93.60  | 87.90    | 88.90 | 0.60     | 0.40  |         | PNLT <sub>m</sub> | 85.30    | 93.40 | 89.50    | 89.40 | 0.80     | 0.70   |
| AL <sub>m</sub>   | 71.20    | 80.90  | 75.10    | 75.70 | 0.50     | 0.30  |         | AL <sub>m</sub>   | 71.40    | 80.70 | 76.40    | 76.10 | 0.50     | 0.40   |
| SEL   | 83.30    | 89.30  | 85.70    | 86.10 | 0.80     | 0.50  |         | SEL               | 83.00    | 89.40 | 87.30    | 86.60 | 0.30     | 0.30   |
| <b>LEVEL FLYOVER</b>  |          |        |          |       |          |       |         |                   |          |       |          |       |          |        |
| EPNL  | 86.60    | 88.20  | 84.90    | 86.60 | 0.30     | 0.20  |         | EPNL              | 86.30    | 89.70 | 85.60    | 87.20 | 0.30     | 0.30   |
| PNLT <sub>m</sub>   | 88.00    | 90.50  | 86.10    | 88.20 | 0.20     | 0.20  |         | PNLT <sub>m</sub> | 87.80    | 91.60 | 86.70    | 88.70 | 0.30     | 0.30   |
| AL <sub>m</sub>   | 71.50    | 74.00  | 71.10    | 72.20 | 0.30     | 0.30  |         | AL <sub>m</sub>   | 71.90    | 75.20 | 71.80    | 73.00 | 0.80     | 0.70   |
| SEL   | 80.40    | 81.50  | 80.10    | 80.70 | 0.20     | 0.20  |         | SEL               | 81.00    | 83.00 | 80.70    | 81.60 | 0.60     | 0.50   |
| <b>TAKEOFF</b>  |          |        |          |       |          |       |         |                   |          |       |          |       |          |        |
| EPNL  | 85.50    | 86.60  | 86.10    | 86.10 | 0.30     | 0.30  |         | EPNL              | 86.30    | 85.70 | 86.20    | 86.00 | 0.10     | 0.00   |
| PNLT <sub>m</sub>   | 86.50    | 87.60  | 86.50    | 86.90 | 0.30     | 0.30  |         | PNLT <sub>m</sub> | 87.40    | 86.90 | 86.40    | 86.90 | 0.20     | 0.10   |
| AL <sub>m</sub>   | 71.30    | 72.60  | 72.00    | 72.00 | 0.30     | 0.30  |         | AL <sub>m</sub>   | 72.30    | 71.80 | 71.20    | 71.80 | 0.40     | 0.40   |
| SEL   | 81.80    | 82.80  | 82.70    | 82.40 | 0.30     | 0.30  |         | SEL               | 82.70    | 82.20 | 82.60    | 82.50 | 0.20     | 0.20   |
| <b>DURATION P</b>   |          |        |          |       |          |       |         |                   |          |       |          |       |          |        |
| APPROACH  | 39.40    | 19.50  | 39.40    |       |          |       |         | APPROACH          | 36.80    | 25.20 | 32.30    |       |          |        |
| LEVEL FLYOVER   | 20.30    | 15.30  | 19.60    |       |          |       |         | LEVEL FLYOVER     | 17.50    | 15.20 | 18.10    |       |          |        |
| TAKEOFF   | 22.30    | 18.20  | 22.40    |       |          |       |         | TAKEOFF           | 22.20    | 15.30 | 19.60    |       |          |        |
| <b>DURATION A</b>   |          |        |          |       |          |       |         |                   |          |       |          |       |          |        |
| APPROACH  | 42.10    | 17.20  | 36.70    |       |          |       |         | APPROACH          | 39.70    | 20.30 | 34.40    |       |          |        |
| LEVEL FLYOVER   | 21.20    | 15.10  | 18.30    |       |          |       |         | LEVEL FLYOVER     | 18.20    | 15.30 | 17.70    |       |          |        |
| TAKEOFF   | 27.00    | 21.80  | 24.50    |       |          |       |         | TAKEOFF           | 25.80    | 23.80 | 27.00    |       |          |        |
| <b>TONE CORRECTION VALUE</b>  |          |        |          |       |          |       |         |                   |          |       |          |       |          |        |
| APPROACH  | 1.10     | 0.70   | 1.30     |       |          |       |         | APPROACH          | 1.00     | 0.70  | 1.30     |       |          |        |
| LEVEL FLYOVER   | 1.90     | 1.00   | 1.30     |       |          |       |         | LEVEL FLYOVER     | 1.70     | 0.80  | 1.40     |       |          |        |
| TAKEOFF   | 2.80     | 2.20   | 2.30     |       |          |       |         | TAKEOFF           | 2.90     | 2.30  | 2.40     |       |          |        |
| <b>TONE CORRECTION BAND</b>   |          |        |          |       |          |       |         |                   |          |       |          |       |          |        |
| APPROACH  | 22       | 25     | 27       |       |          |       |         | APPROACH          | 22       | 25    | 27       |       |          |        |
| LEVEL FLYOVER   | 22       | 23     | 23       |       |          |       |         | LEVEL FLYOVER     | 22       | 23    | 27       |       |          |        |
| TAKEOFF   | 22       | 22     | 22       |       |          |       |         | TAKEOFF           | 22       | 22    | 22       |       |          |        |
| <b>MAX NOY BAND</b>   |          |        |          |       |          |       |         |                   |          |       |          |       |          |        |
| APPROACH  | 24,27,25 |        | 25,24,26 |       | 24,23,24 |       |         | APPROACH          | 23,24,26 |       | 25,26,26 |       | 24,23,26 |        |
| LEVEL FLYOVER   | 22,29,32 |        | 24,26,27 |       | 22,32,25 |       |         | LEVEL FLYOVER     | 22,32,NA |       | 23,26,22 |       | 22,24,NA |        |
| TAKEOFF   | 22,24,32 |        | 22,34,35 |       | 24,22,29 |       |         | TAKEOFF           | 22,24,29 |       | 22,NA,26 |       | 22,24,29 |        |
| <b>STATIC FLIGHT IDLE</b>   |          |        |          |       |          |       |         |                   |          |       |          |       |          |        |
| 0   | 45       | 90     | 135      | 180   | 225      | 270   | 315     |                   |          |       |          |       |          |        |
| HARD  | 64.80    | 65.80  | 65.60    | 68.90 | 65.30    | 66.30 | 67.60   | 66.10             |          |       |          |       |          |        |
| SOFT  | 54.00    | 59.20  | 59.40    | 63.70 | 57.50    | 59.80 | 59.50   | 56.10             |          |       |          |       |          |        |
| THE DATA WHICH APPEARS IN THIS TABLE WAS<br>DERIVED FROM THE FRG DECEMBER 1985<br>REPORT, WITH THE EXCEPTION OF THE STATIC<br>DATA AND CORRECTIONS TO THE APPROACH<br>DATA WHICH CAME FROM A SEPTEMBER<br>1986 SUBMITTAL. |          |        |          |       |          |       |         |                   |          |       |          |       |          |        |

#### 5.4.8 United Kingdom Team

##### 5.4.8.a Tracking Equipment

The UK ground tracking stations employed Polaroid 600 (or 600SE) cameras with 127mm lenses mounted on photographic tripods. Each camera was equipped with a 27 MHz radio transmitter, which when triggered produced an amplitude modulated carrier at 1kHz for approximately 1 second. This signal was picked up by 27 Mhz receivers connected to the auxiliary channel of the Nagra tape recorders at the adjacent acoustical measurement sites and within the helicopter.

##### 5.4.8.b Acoustical Data Acquisition Instrumentation

For the UK participant, noise recordings were made by teams from Westland Helicopter Ltd., while direct read measurements (and weather data) were obtained by British Aerospace. For the purposes of this report, only the noise recorded measurements are discussed.

The UK measuring systems at the centerline-center measurement site consisted of a 1.2 m microphone system and a ground surface system, which fed into separate channels of the site's 2-channel Nagra tape recorder. The ground microphone was inverted with its diaphragm 7mm above a closely cropped grass surface. The three other noise measurements sites were each equipped with a single 1.2 microphone system. Figure 5.4.G is a schematic diagram of a the UK acoustical data acquisition instrumentation; included in the figure are the systems equipment specifications.

##### 5.4.8.c Noise Data Reduction

Processing of the tape recorded acoustic signals was carried out using the Westland Acoustics Laboratory's analysis system, which consists of the following equipment:

- Gen Rad 1995 Integrated 1/3 Octave Real Time Analyzer
- Nicolet 660A dual channel FFT analyzer
- Hewlett Packard 9845 B desktop computer including:
  - 578 k bytes RAM
  - 2 - 9885 flexible disk drives
  - 9872 B A3 plotter
- Hewlett Packard 7045 B A3 X-Y plotter

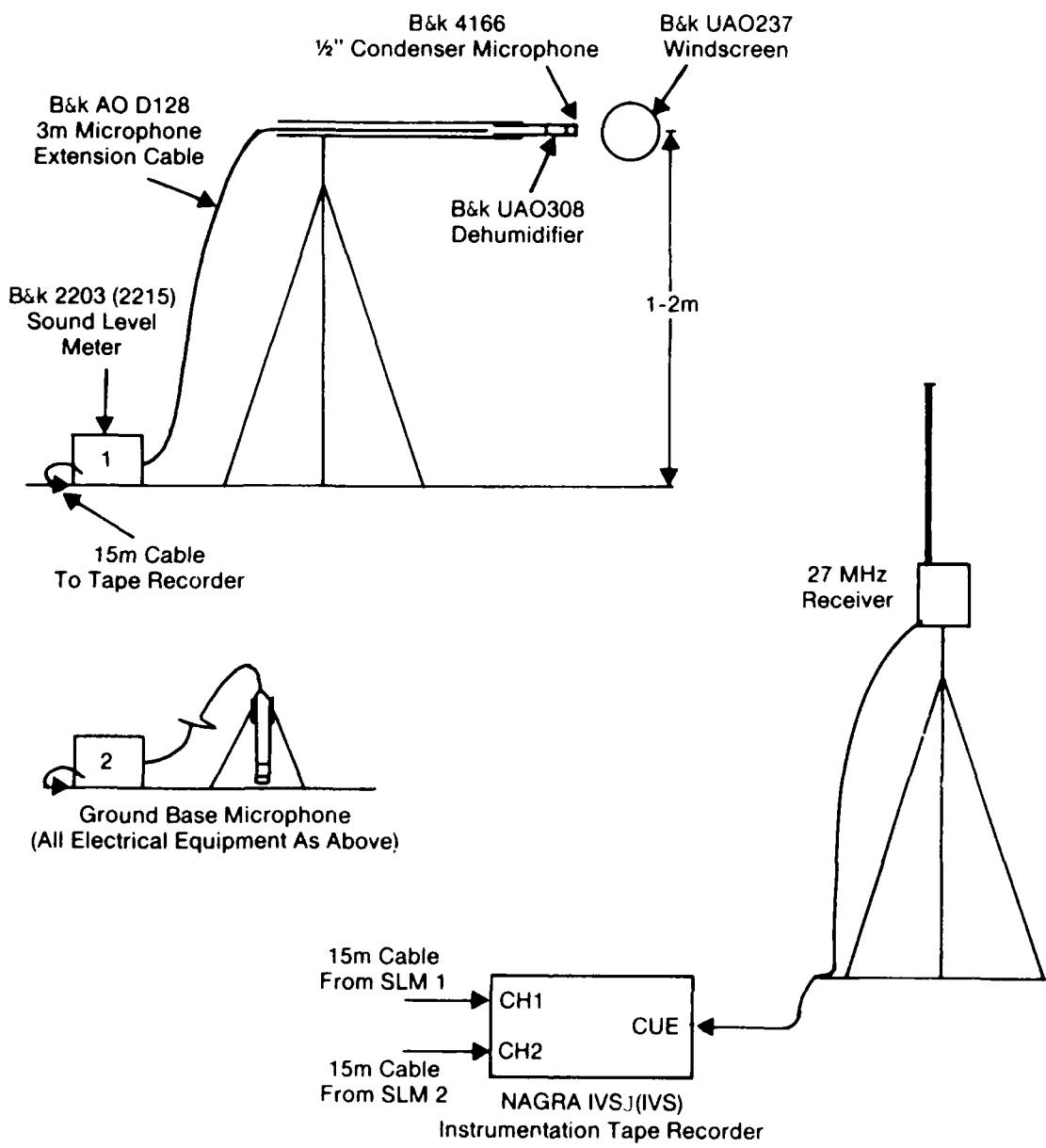
The two spectrum analyzers are linked to the computer via HP-IB (IEEE -488, 1978) and 16-bit parallel interfaces (Nicolet only) providing an extremely flexible facility.

##### 5.4.8.d Final Summary Data

The data in the UK final corrected data summary table, Table 5.4.C, uses data from the UK December 1985 submittal, with corrections to the level flyover data coming from the September 1986 submittal.

**Figure 5.4.G**

**UK Noise Measurement/Recording System Instrumentation**



NOTES: 1. Ground Based Microphone at Position 1 Only  
2. Equipment Types in Parentheses at Microphone 4

Table 5.4.C

UNITED KINGDOM FINAL CORRECTED DATA

| PILOT 1                      |          |        |          |       |          |      | PILOT 2   |                    |       |          |       |          |      |      |        |
|------------------------------|----------|--------|----------|-------|----------|------|---|--------------------|-------|----------|-------|----------|------|------|--------|
|                              | LEFT     | CENTER | RIGHT    | ZMIC  | STD      | DEV  | 90% CI  |                    | LEFT  | CENTER   | RIGHT | ZMIC     | STD  | DEV  | 90% CI |
| <b>APPROACH</b>              |          |        |          |       |          |      | <b>APPROACH</b>   |                    |       |          |       |          |      |      |        |
| EPNL                         | 86.20    | 92.30  | 89.90    | 89.50 | 0.50     | 0.40 |   | EPNL               | NA    | NA       | NA    | NA       | NA   | NA   |        |
| PNLT <sub>th</sub>           | 95.40    | 93.80  | 89.60    | 89.70 | 0.80     | 0.70 |   | PNLT <sub>th</sub> | NA    | NA       | NA    | NA       | NA   | NA   |        |
| ALR                          | 71.90    | 81.20  | 76.50    | 76.60 | 0.90     | 0.70 |   | ALR                | NA    | NA       | NA    | NA       | NA   | NA   |        |
| SEL                          | 82.90    | 89.60  | 87.40    | 86.60 | 0.50     | 0.40 |   | SEL                | NA    | NA       | NA    | NA       | NA   | NA   |        |
| <b>LEVEL FLYOVER</b>         |          |        |          |       |          |      | <b>LEVEL FLYOVER</b>  |                    |       |          |       |          |      |      |        |
| EPNL                         | 88.10    | 89.00  | 85.20    | 87.50 | NA       | NA   |   | EPNL               | NA    | NA       | NA    | NA       | NA   | NA   |        |
| PNLT <sub>th</sub>           | 93.40    | 92.20  | 86.90    | 89.90 | NA       | NA   |   | PNLT <sub>th</sub> | NA    | NA       | NA    | NA       | NA   | NA   |        |
| ALR                          | 72.80    | 75.40  | 72.30    | 73.50 | 0.30     | 0.20 |   | ALR                | NA    | NA       | NA    | NA       | NA   | NA   |        |
| SEL                          | 81.60    | 82.50  | 80.70    | 81.70 | 0.20     | 0.20 |   | SEL                | NA    | NA       | NA    | NA       | NA   | NA   |        |
| <b>TAKEOFF</b>               |          |        |          |       |          |      | <b>TAKEOFF</b>  |                    |       |          |       |          |      |      |        |
| EPNL                         | 86.00    | 87.30  | 85.50    | 86.60 | 0.40     | 0.30 |   | EPNL               | 86.40 | 86.50    | 87.20 | 87.80    | 0.20 | 0.20 |        |
| PNLT <sub>th</sub>           | 86.70    | 88.50  | 86.80    | 87.30 | 0.30     | 0.30 |   | PNLT <sub>th</sub> | 87.30 | 87.70    | 87.20 | 87.40    | 0.30 | 0.30 |        |
| ALR                          | 72.00    | 73.90  | 72.90    | 72.90 | 0.30     | 0.30 |   | ALR                | 72.80 | 72.80    | 73.20 | 72.90    | 0.00 | 0.00 |        |
| SEL                          | 81.50    | 83.70  | 83.50    | 83.20 | 0.30     | 0.30 |   | SEL                | 82.50 | 83.00    | 84.10 | 83.70    | 0.30 | 0.20 |        |
| <b>DURATION P</b>            |          |        |          |       |          |      | <b>DURATION P</b>   |                    |       |          |       |          |      |      |        |
| APPROACH                     | 37.00    | 17.00  | 26.20    |       | NA       | NA   | NA  | APPROACH           | NA    | NA       | NA    |          |      |      |        |
| LEVEL FLYOVER                | 19.90    | 12.20  | 16.30    |       | NA       | NA   | NA  | LEVEL FLYOVER      | NA    | NA       | NA    |          |      |      |        |
| TAKEOFF                      | 23.60    | 15.20  | 22.80    |       | NA       | NA   | NA  | TAKEOFF            | 22.30 | 17.30    | 25.30 |          |      |      |        |
| <b>DURATION A</b>            |          |        |          |       |          |      | <b>DURATION A</b>   |                    |       |          |       |          |      |      |        |
| APPROACH                     | 38.80    | 17.10  | 32.60    |       | NA       | NA   | NA  | APPROACH           | NA    | NA       | NA    |          |      |      |        |
| LEVEL FLYOVER                | 21.00    | 12.80  | 19.80    |       | NA       | NA   | NA  | LEVEL FLYOVER      | NA    | NA       | NA    |          |      |      |        |
| TAKEOFF                      | 26.20    | 19.20  | 23.80    |       | NA       | NA   | NA  | TAKEOFF            | 21.80 | 22.60    | 26.10 |          |      |      |        |
| <b>TONE CORRECTION VALUE</b> |          |        |          |       |          |      | <b>TONE CORRECTION VALUE</b>  |                    |       |          |       |          |      |      |        |
| APPROACH                     | 0.90     | 0.90   | 1.00     |       | NA       | NA   | NA  | APPROACH           | NA    | NA       | NA    |          |      |      |        |
| LEVEL FLYOVER                | 1.30     | 1.20   | 1.20     |       | NA       | NA   | NA  | LEVEL FLYOVER      | NA    | NA       | NA    |          |      |      |        |
| TAKEOFF                      | 2.70     | 2.20   | 2.70     |       | NA       | NA   | NA  | TAKEOFF            | 2.70  | 2.10     | 2.60  |          |      |      |        |
| <b>TONE CORRECTION BAND</b>  |          |        |          |       |          |      | <b>TONE CORRECTION BAND</b>   |                    |       |          |       |          |      |      |        |
| APPROACH                     | 24       | 24     | 26       |       | NA       | NA   | NA  | APPROACH           | NA    | NA       | NA    |          |      |      |        |
| LEVEL FLYOVER                | 22       | 23     | 23       |       | NA       | NA   | NA  | LEVEL FLYOVER      | NA    | NA       | NA    |          |      |      |        |
| TAKEOFF                      | 22       | 22     | 23       |       | NA       | NA   | NA  | TAKEOFF            | 22    | 22       | 22    |          |      |      |        |
| <b>MAX NOY BANDS</b>         |          |        |          |       |          |      | <b>MAX NOY BANDS</b>  |                    |       |          |       |          |      |      |        |
| APPROACH                     | 24.23,24 |        | 25.25,25 |       | 26.25,25 |      | APPROACH  | NA,NA,NA           |       | NA,NA,NA |       | NA,NA,NA |      |      |        |
| LEVEL FLYOVER                | 22.27,26 |        | 24.24,26 |       | 22.31,27 |      | LEVEL FLYOVER   | NA,NA,NA           |       | NA,NA,NA |       | NA,NA,NA |      |      |        |
| TAKEOFF                      | 22.24,21 |        | 22.27,22 |       | 22.27,27 |      | TAKEOFF   | 22.24,19           |       | 22.28,21 |       | 22.28,21 |      |      |        |
| <b>STATIC FLIGHT ISLE</b>    |          |        |          |       |          |      | THE DATA WHICH APPEAR IN THIS TABLE IS FROM THE DECEMBER 1995 SUBMITTAL WITH CORRECTION TO THE LEVEL FLYOVER DATA COMING FROM THE SEPTEMBER 1995 SUBMITTAL. |                    |       |          |       |          |      |      |        |
| 0                            | 45       | 91     | 173      | 187   | 225      | 272  | 315   |                    |       |          |       |          |      |      |        |
| HARD                         | 67.0     | 67.2   | 65.7     | 68.2  | 67.9     | 64.2 | 65.0  | 67.1               |       |          |       |          |      |      |        |
| SOFT                         | 54.9     | 58.6   | 59.1     | 67.1  | 59.2     | 61.7 | 59.9  | 59.7               |       |          |       |          |      |      |        |

THE DATA WHICH APPEAR IN THIS TABLE IS FROM THE CITY DECEMBER 1985 SUBMITTAL WITH CORRECTION ONE TO THE LEVEL FIVE AND DATA COMING FROM THE SEPTEMBER 1985 SUBMITTAL.

UK delta 3 calculated at 15°C

## 5.5 UNITED STATES - CANADIAN TEST

The joint United States/Canadian noise measurement flight test was held August 27th through 29th, 1984 at Dulles International Airport near Washington, DC, USA. The United States (US) test team was comprised of US Department of Transportation (DOT) personnel from the Federal Aviation Administration (FAA) and the Transportation Systems Center (TSC). The Canadian team was comprised of personnel from the Canadian Ministry of Transport.

### 5.5.1 Weather

The weather for the US/Canadian noise measurement flight test was clear and sunny. Core program test events occurred from 8:00 am to 1:00 pm EST, during which time temperatures ranged from 18 degrees Celsius to 27 degrees Celsius.

### 5.5.2 Operations

The static and flight operations conducted as part of the US/Canadian flight test program are outlined in Table 5.5.A. The core test program (detailed in Section 3.2) was conducted twice by two different pilots, thus establishing a data base of four complete core tests within this single flight test program.

**Table 5.5.A**

US-CANADIAN FLIGHT TEST PROGRAM

| ** |      |       |                                    | ** |      |       |                                    |
|----|------|-------|------------------------------------|----|------|-------|------------------------------------|
| ID | OCRN | PILOT | OPERATION                          | ID | OCRN | PILOT | OPERATION                          |
| A  | 1    | 1     | Level Flyover 0.9Vh                | AZ | 2    | 1     | Level Flyover 0.9Vh                |
| AA | 1    | 2     | Level Flyover 0.9Vh                | AY | 2    | 2     | Level Flyover 0.9Vh                |
| B  | 1    | 1     | ICAO Takeoff, Vy                   | BZ | 2    | 1     | ICAO Takeoff, Vy                   |
| BB | 1    | 2     | ICAO Takeoff, Vy                   | BY | 2    | 2     | ICAO Takeoff, Vy                   |
| C  | 1    | 1     | Six Degree Approach                | CZ | 2    | 1     | Six Degree Approach                |
| CC | 1    | 2     | Six Degree Approach                | CY | 2    | 2     | Six Degree Approach                |
| D  | 1    | 1     | Static FI                          | DZ | 2    | 1     | Static FI                          |
| E  | 1    | 1     | Static GI                          | EZ | 2    | 1     | Static GI                          |
| F  | 1    | 1     | Static HIGE                        | FZ | 2    | 1     | Static HIGE                        |
| M  | 1    | 1     | Bell Quiet Approach                | MM | 2    | 1     | Bell Quiet Approach                |
| K  | 1    | 1     | Six Degree Approach<br>No Guidance | KK | 2    | 1     | Six Degree Approach<br>No Guidance |
| G  | 1    | 1     | Level Flyover 0.9Vh (300m)         |    |      |       |                                    |
| H  | 1    | 1     | Level Flyover 1.0Vh (150m)         |    |      |       |                                    |
| I  | 1    | 1     | Level Flyover 0.8Vh (150m)         |    |      |       |                                    |
| J  | 1    | 1     | Level Flyover 0.7Vh (150m)         |    |      |       |                                    |

\*\* OCCURRENCE - First or second time pilot flew operation.

### 5.5.3 Pilots

The US/Canadian flight test program pilots were: Pilot 1 from Omnidflight Airways (Baltimore, Maryland, USA) and Pilot 2 from the FAA. As mentioned above, the core test program was flown twice by each pilot. Included in Table 5.5.A are notations as to which pilot flew which event.

### 5.5.4 Test Helicopter

The Bell 206L-1 used during the US/Canadian test program was leased by Bell Helicopter, Textron from Omnidflight Airways (Baltimore, Maryland, USA).

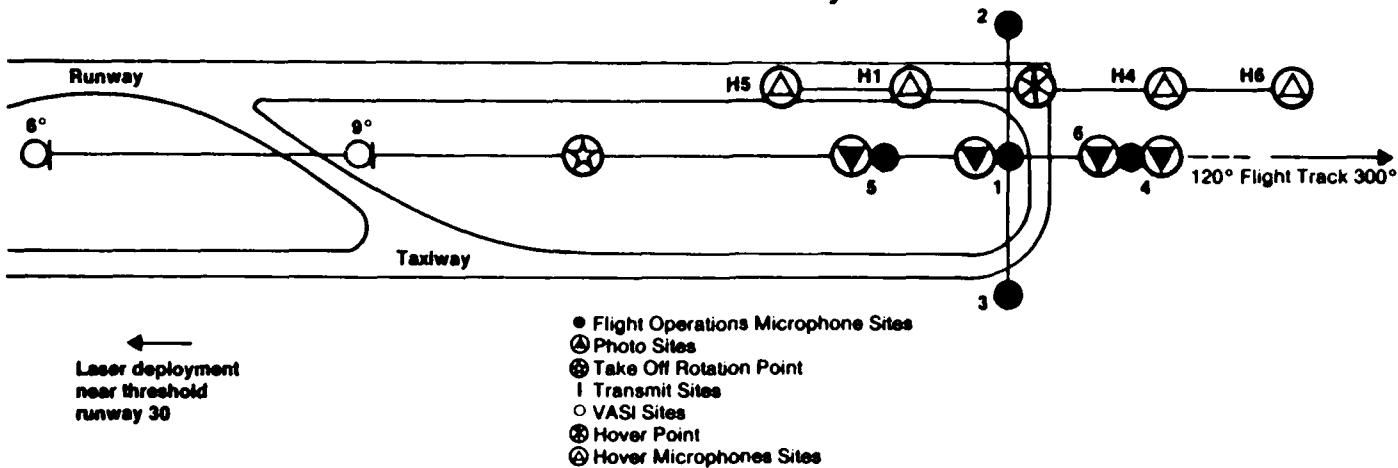
Prior to the test, a laser retro-reflector was mounted on the underside of the test helicopter for tracking purposes. The retro-reflector constitutes the only external modification to the US test helicopter.

### 5.5.5 Test Site Array

The US/Canadian test site array was an enhancement of the HNMRP test plan specifications. The flight operation test site array consisted of the certification sites (a centerline-center and two sideline sites), the HNMRP recommended down-range centerline site, and an additional centerline site, located 150 meters up-range from the centerline-center site (for a total of three centerline sites). The test site array for static operations included the requested 150 m hard and soft propagation path sites plus two additional sites, one hard and one soft propagation located 300 meters from the hover point. Figure 5.5.A is a schematic diagram of the test site array.

**Figure 5.5.A**

**US/Canadian Test Array**



The noise measurement testing area was nominally flat, with a ground cover of short, clipped grass. It was bordered on the north, south, and west by woods, which provided a low ambient noise level. The runway adjacent to the test area was closed during the test, so there was minimum interference from commercial or general aviation.

## 5.5.6 Joint Program Features

### 5.5.6.a Approach Guidance System

Approach guidance was provided to the pilots by means of a Visual Approach Slope Indicator (VASI). The VASI was located at the point where the approach path intercepted the ground, at a distance of 1128 meters (3701 feet) from the centerline-center site. The system used in the test was a three-light arrangement giving vertical displacement information within  $\pm 0.5$  degrees of the reference approach slope. The pilot observed a green light if the helicopter was within 0.5 degrees of the approach slope, red if below the approach slope, white if above.

In the case of verbal guidance approaches, FAA personnel operating a surveying theodolite advised the flight crew of deviations (exceeding 0.5 degrees) from the reference six degree flight path.

### 5.5.6.b Tracking Systems

During the US/Canadian HNMRF flight test three separate tracking systems (laser, radar and photographic) were used in order compare the systems and to assure complete acquisition of tracking data. Below is a description of each tracking system. Measurement and reduction of tracking data was the responsibility of the US team with the resulting tracking data used by both teams to reduce their noise data.

Laser - The laser precision automated tracking system used during the US/Canadian HNMRF flight test is a semi-mobile facility which uses an invisible laser beam to automatically track aircraft equipped with a retro-reflector.

The tracking portion of the system consists of a laser transmitter and an optical receiver. Short bursts of infrared laser energy are generated in a narrow beam toward the target and are returned to a receiving telescope. The receiving telescope's optical output is then directed to a 4-quadrant photo detector. When the telescope axis is pointed precisely at the tracked target, all quadrants of the photo detector receive an equal portion of the target return image, and the detector outputs are equal. An optical automatic gain control system operates a filter wheel in conjunction with the laser transmitter optical attenuators to maintain constant average optical signal levels at the quadrant photo detector. When the target is off of the telescope axis, detector outputs are unequal and a function of the magnitude and direction of the pointing error; the necessary adjustments are then made automatically to maintain target tracking.

Initial locking of the laser transmitter onto the aircraft's retro-reflector is made with video-optical sighting equipment which is linked to a television camera mounted below the receiving telescope and aligned with the tracking optical axis. After the camera sights the aircraft, the system begins tracking automatically.

Range is obtained by measuring the time interval between transmitted and received optical pulses. The range computer is initialized each time the

laser is fired. If no target return pulse is received and automatic and manual operations fail to acquire the target the computer disregards the data sample. Range to the tracked target is measured and displayed with a resolution of 1 foot in 5 miles.

The data processing portion of the laser system consists of a Digital Equipment Corporation PDP-11/35 processor and related equipment. The accuracy for both azimuth and elevation is 20 arc seconds. During tracking, the data processing system exercises control over the tracking system and formats the tracking data for recording and display. After tracking is completed, tracking data are recorded on magnetic tape.

Radar - The radar system deployed during the US/Canadian flight test is a semi-mobile 9.1 GigaHertz radar system. The radar locates the target with the assistance of a video camera which is mounted below the radar transmitting/receiving antenna. Once the operator controlled video system has the target in an acquisition window, the radar system locks on.

The radar determines the range of the helicopter by analyzing the reflected electromagnetic pulse from the aircraft. The target's spherical coordinates, range, elevation and azimuth are outputted, along with IRIG-B time code, to a Kennedy one inch magnetic tape drive. The magnetic tape was subsequently reduced in the FAA acoustical laboratory using a PDP-11-35 computer system. Raw data were then converted to Cartesian coordinates, and the required position information was computed, tabulated and plotted.

Photo Altitude Determination System - Helicopter position data were also acquired by using the photo altitude determination system, which is described in the Society of Automotive Engineers report AIR-902 (Ref 11) and which was used by several other HNMRF participants.

Problems were encountered with each of the three tracking systems throughout the program. The laser system's problems included failure of the diesel electric generator power supply and difficulty locking onto the retro-reflector during some operations. The radar system experienced data drop-out when the tracking antenna would lock-up on strong stationary electromagnetic targets. There were also problems with the radar's recording tape drive transport mechanism. The photographic crew universally experienced difficulty during the test in their attempts to provide time synchronized photographs through use of time indexed data backs, or range code synchronized stop watches. Fortunately, with three systems, tracking data were available on most of the events.

Laser data were used as the tracking data, when available, because it is the most accurate of the three systems (1 foot in 5 miles). Laser data, however, were only available for approximately one-third of the total number of program events (both core and elective operations). As such, in cases where laser data were unavailable, photo data were used together with radar data, creating Photo Adjusted Radar data (PAR). PAR data were generated in the following manner:

$$\text{CPA(PAR)} = \text{photo CPA}$$

$$\text{SR(PAR)} = \frac{\text{Photo CPA} * \text{Radar SR}}{\text{Radar CPA}}$$

### 5.5.6.c Meteorological Systems

For the US/Canadian HNMRP flight test a Doppler Sodar was used to acquire a detailed description of the wind structure in the immediate vicinity of the noise measurement sites. The Sodar measures wind speed and direction by sending an acoustical pulse into the atmosphere, via three large conically shaped antenna, and measuring the intensity of the returning pulse echo. The frequency shift of the echo varies according to the wind speed (doppler effect), while the echo intensity varies according to thermal turbulence and structure. A DEC PDP-1103 computer processed the information received from the pulse echoes and stored the output on magnetic tape. The accuracy of the Remtech Doppler Sodar system is 0.3 meters per second for wind speed and 3 degrees for wind direction.

A ten meter meteorological tower was used to measure: temperature, relative humidity, wind speed and wind direction during the test. Both meteorological systems were deployed and operated by the US team and the subsequent data was shared by the two teams.

### 5.5.6.d Cockpit Data Documentation

During the US/Canadian noise measurement flight test, helicopter performance characteristics were documented by the use of a cockpit videotape system similar to those used in the other HNMRP flight test programs. A flight observer's log of the average instrument readings for each event was also kept.

## 5.5.7 Canadian Team

### 5.5.7.a Acoustical Acquisition Systems

The Canadian acoustical acquisition systems consisted of both analog and digital magnetic recording systems. The analog systems were deployed at the sideline sites, while the digital systems were deployed at the three centerline sites. An inverted (ground-plane) microphone, using a digital magnetic recording system, was also deployed at the centerline-center site.

Both the analog and the digital systems included condenser microphones with preamps operated by battery driven B&K 2804 power supplies.

For the analog systems, the power supplies were modified to provide 30 dB extra gain (via an internal toggle switch). Fifty meter cables were used to connect the power supplies to the B&K 7003 four channel magnetic tape recorders. The four recorder channels (Ch) were used as follows:

Ch-1 cue channel

Ch-2 acoustic data were recorded as linear or flat weighting

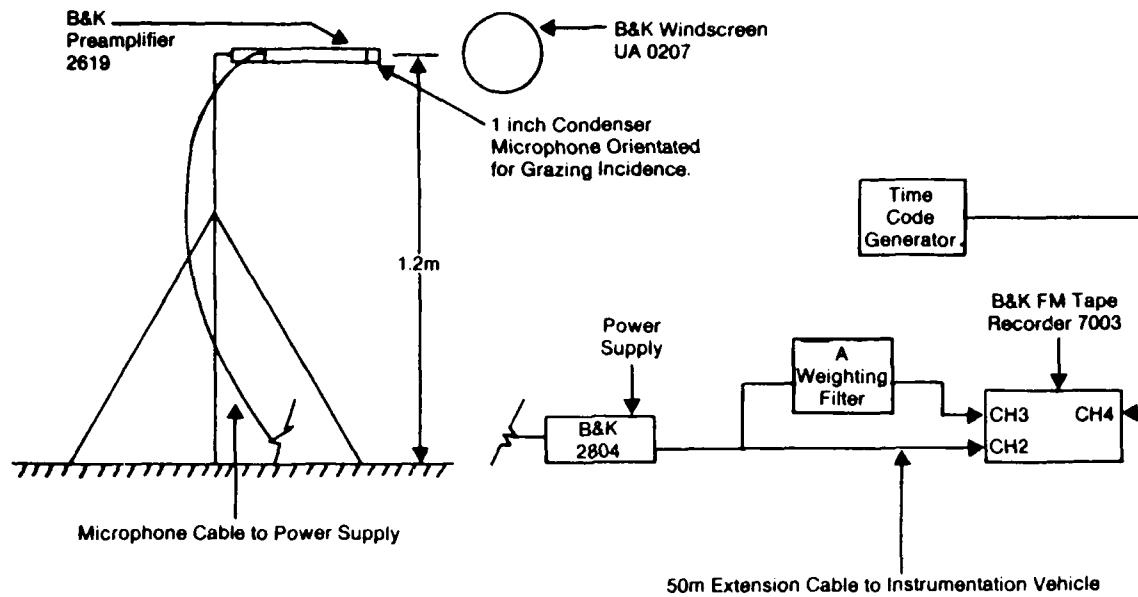
Ch-3 acoustic data were passed through an A-weighted filter

Ch-4 Inter Range Instrumentation Group-B (IRIG-B) synchronized time code

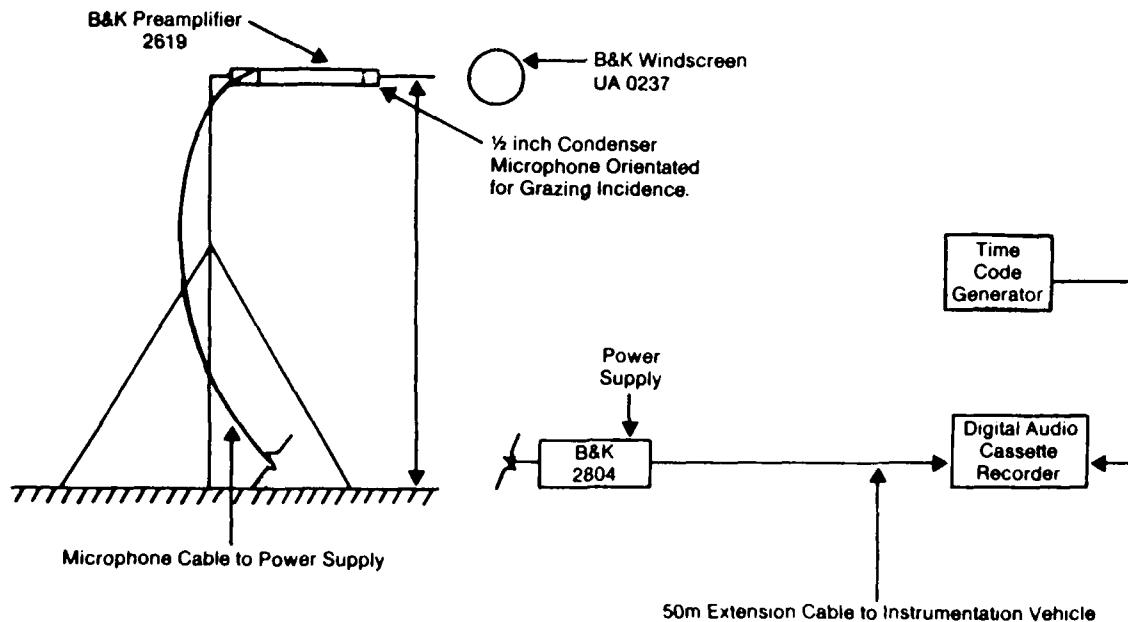
The A-weighted filter was employed in case the dynamic range of the tape recorder (approximately 40-50 dB) was inadequate for the large level

## Figure 5.5.B

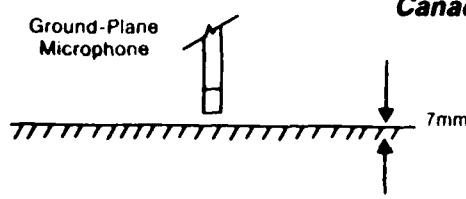
### *Canadian Analog Acoustical Data Acquisition System*



## Figure 5.5.C



### *Canadian Digital Acoustical Data Acquisition System*



differences (30 to 60 dB) between the high and low frequencies which characterize helicopter acoustic signals. Recording gains were set so that the optimal signal-to-noise ratio would be achieved while allowing sufficient "head-room" to avoid distortion of the peak levels.

The digital systems employed were Panasonic and Technics Digital Audio Cassette Recorders, types SVP-100 and SV-100, for the ground-plane and conventional microphone systems respectively. 14 Bit AD-DA converters and Pulse Code Modulation (PCM) Encoder/Decoders were used with both, and acoustic data were recorded on VHS video cassettes. These systems have a wide dynamic range, approximately 85 dB, and thus no high frequency pre-emphasis was necessary. AC power was provided by means of 12 Volt DC batteries and a static inverter.

The analog and digital systems are shown in Figures 5.5.B and 5.5.C, respectively.

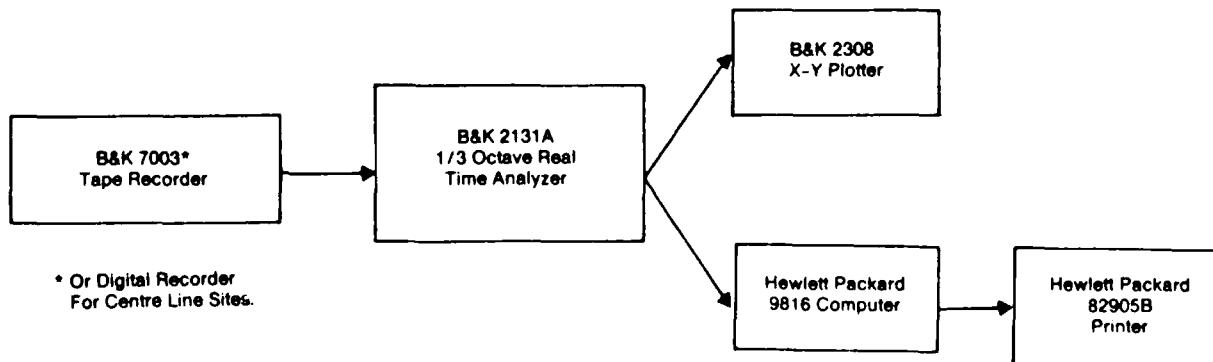
#### 5.5.7.b Acoustic Data Reduction and Processing

The magnetic tape recording field data were reduced and processed at De Havilland of Canada, Toronto Division. Additional processing was performed at Transport Canada. Figure 5.5.D is a schematic of the data reduction and analysis system used.

Corrections were applied to the data to account for non-standard acoustical day conditions, source noise characteristics and aircraft deviations from the reference flight track and speed. These corrections, as well as the prior data reduction and analysis were conducted in accordance with the procedures detailed in the HNMMP reference documentation. Included in these corrections were the Annex 16 Delta 1, 2, and 3 corrections.

**Figure 5.5.D**

#### ***Canadian Acoustic Data Reduction and Analysis System***



#### 5.5.7.c Final Data Summary

The data which appears in the Canada "Final Corrected Data Summary", Tables 5.5.B and 5.5.C, were derived from the Canadian April 1986 "ICAO HNMMP US/CANADA JOINT PROGRAM, CANADIAN TEST REPORT" (R-86-2) and from September 1986 submittals.

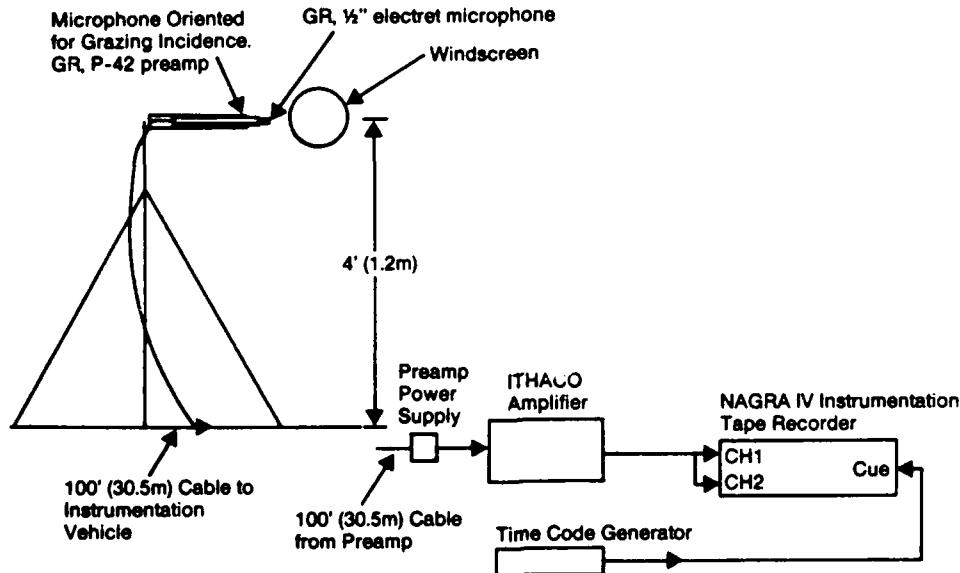
#### 5.5.8 United States' Team

##### 5.5.8.a Acoustic Measurement Instrumentation

Nagra two-channel direct-mode tape recorder systems, shown in Figure 5.5.E,

## Figure 5.5.E

### **US Noise Measurement/Recording System Instrumentation**



were deployed by the US team at each acoustical measurement site. On one channel the noise data were recorded with essentially flat frequency response, while on the second channel the data were first weighted and amplified using a high pass pre-emphasis filter.

Helicopter acoustical signals are characterized by large level differences (30 to 60 dB) between the high and low frequencies and as such the use of pre-emphasis was deemed necessary in order to boost the high frequency portion of the acoustical signal. The pre-emphasis network rolled off those frequencies below 10,000 Hz at 20 dB per decade. Recording gains were adjusted so that the best possible signal-to-noise ratio would be achieved while allowing enough "head room" to comply with applicable distortion avoidance requirements.

#### **5.5.8.b      Noise Data Reduction**

The analog magnetic tape recordings were analyzed at the Transportation Systems Center (TSC) facility in Cambridge, Massachusetts, USA. Data reduction followed the basic procedures defined in the references outlined in Section 2.3 of this report. Delta 1 and 2 corrections were applied to all operations as per Annex 16 procedures, and in the case of the level flyover operation Delta 3 source noise corrections were also applied.

#### **5.5.8.c      Final Summary Data**

The "US Test Report" is the source of the final US data presented in Tables 5.5.D and 5.5.E. The "US Test Report" was prepared before the HNMRF group agreed on the left-center-right-3 microphone data table format so the US data have been presented in Appendix C in that format.

# Table 5.5.B

CANADA FINAL CORRECTED DATA

|                              | PILOT 1-1 |        |          |       |          |        | PILOT 1-2         |          |           |          |       |        |      |
|------------------------------|-----------|--------|----------|-------|----------|--------|-------------------|----------|-----------|----------|-------|--------|------|
|                              | LEFT      | CENTER | RIGHT    | 3MIC  | STD      |        | LEFT              | CENTER   | RIGHT     | 3MIC     | STD   |        |      |
|                              |           |        |          |       | DEV      | 90% CI |                   |          |           |          | DEV   | 90% CI |      |
| <b>APPROACH</b>              |           |        |          |       |          |        |                   |          |           |          |       |        |      |
| EPNL                         | NA        | NA     | NA       | NA    | NA       | NA     | EPNL              | 86.97    | 92.92     | 91.81    | 90.57 | 0.13   | 0.58 |
| PNLT <sub>m</sub>            | NA        | NA     | NA       | NA    | NA       | NA     | PNLT <sub>m</sub> | 86.82    | 94.82     | 90.97    | 90.86 | 0.32   | 1.44 |
| AL <sub>m</sub>              | NA        | NA     | NA       | NA    | NA       | NA     | AL <sub>m</sub>   | 71.35    | 82.25     | 77.32    | 76.97 | 0.12   | 0.53 |
| SEL                          | NA        | NA     | NA       | NA    | NA       | NA     | SEL               | 82.68    | 90.34     | 88.42    | 87.15 | 0.13   | 0.58 |
| <b>LEVEL FLYOVER</b>         |           |        |          |       |          |        |                   |          |           |          |       |        |      |
| EPNL                         | 88.59     | 88.67  | 88.34    | 88.54 | 0.22     | 0.21   | EPNL              | 88.55    | 88.38     | 87.23    | 88.07 | 0.58   | 0.68 |
| PNLT <sub>m</sub>            | 88.98     | 90.38  | 89.44    | 89.57 | 0.27     | 0.26   | PNLT <sub>m</sub> | 89.76    | 91.27     | 87.56    | 89.53 | 0.60   | 0.71 |
| AL <sub>m</sub>              | 74.29     | 76.43  | 74.82    | 75.18 | 0.48     | 0.46   | AL <sub>m</sub>   | 73.94    | 76.88     | 73.02    | 74.61 | 0.69   | 0.81 |
| SEL                          | 84.31     | 85.08  | 83.88    | 84.43 | 0.32     | 0.31   | SEL               | 83.62    | 84.52     | 82.30    | 83.48 | 0.60   | 0.71 |
| <b>TAKEOFF</b>               |           |        |          |       |          |        |                   |          |           |          |       |        |      |
| EPNL                         | 87.76     | 87.35  | 87.75    | 87.62 | 0.17     | 0.29   | EPNL              | 88.54    | 87.10     | 85.93    | 87.19 | 0.08   | 0.35 |
| PNLT <sub>m</sub>            | 88.82     | 88.85  | 88.36    | 88.68 | 0.55     | 0.93   | PNLT <sub>m</sub> | 99.41    | 98.58     | 86.34    | 88.11 | 0.02   | 0.07 |
| AL <sub>m</sub>              | 73.11     | 73.82  | 72.48    | 73.14 | 0.08     | 0.14   | AL <sub>m</sub>   | 73.31    | 74.03     | 70.69    | 72.67 | 0.03   | 0.14 |
| SEL                          | 83.71     | 83.53  | 83.49    | 83.57 | 0.32     | 0.54   | SEL               | 84.21    | 83.54     | 81.86    | 83.20 | 0.26   | 1.16 |
| <b>DURATION P</b>            |           |        |          |       |          |        |                   |          |           |          |       |        |      |
| APPROACH                     | NA        | NA     | NA       |       |          |        | APPROACH          | 25.30    | 17.00     | 27.50    |       |        |      |
| LEVEL FLYOVER                | 22.70     | 16.50  | 17.70    |       |          |        | LEVEL FLYOVER     | 18.70    | 11.90     | 21.20    |       |        |      |
| TAKEOFF                      | 23.10     | 17.30  | 25.30    |       |          |        | TAKEOFF           | 28.10    | 15.50     | 24.30    |       |        |      |
| <b>DURATION A</b>            |           |        |          |       |          |        |                   |          |           |          |       |        |      |
| APPROACH                     | NA        | NA     | NA       |       |          |        | APPROACH          | 20.20    | 15.40     | 26.10    |       |        |      |
| LEVEL FLYOVER                | 22.85     | 16.60  | 17.50    |       |          |        | LEVEL FLYOVER     | 20.00    | 12.00     | 18.70    |       |        |      |
| TAKEOFF                      | NA        | 19.40  | 28.20    |       |          |        | TAKEOFF           | 31.80    | 22.70     | 26.10    |       |        |      |
| <b>TONE CORRECTION VALUE</b> |           |        |          |       |          |        |                   |          |           |          |       |        |      |
| APPROACH                     | NA        | NA     | NA       |       |          |        | APPROACH          | 1.40     | 1.00      | 1.30     |       |        |      |
| LEVEL FLYOVER                | 1.78      | 1.10   | 1.44     |       |          |        | LEVEL FLYOVER     | 1.80     | 1.20      | 1.30     |       |        |      |
| TAKEOFF                      | 2.60      | 2.20   | 2.40     |       |          |        | TAKEOFF           | 2.70     | 2.30      | 2.50     |       |        |      |
| <b>TONE CORRECTION BAND</b>  |           |        |          |       |          |        |                   |          |           |          |       |        |      |
| APPROACH                     | NA        | NA     | NA       |       |          |        | APPROACH          | NA       | 25        | NA       |       |        |      |
| LEVEL FLYOVER                | NA        | 23     | NA       |       |          |        | LEVEL FLYOVER     | NA       | 23        | NA       |       |        |      |
| TAKEOFF                      | NA        | 22     | 22       |       |          |        | TAKEOFF           | NA       | 22        | 22       |       |        |      |
| <b>MAX NOY BANDS</b>         |           |        |          |       |          |        |                   |          |           |          |       |        |      |
| APPROACH                     | NA,NA,NA  |        | NA,NA,NA |       | NA,NA,NA |        | APPROACH          | NA,NA,NA | 25,26,26  | 23,NA,NA |       |        |      |
| LEVEL FLYOVER                | NA,NA,NA  |        | 23,26,27 |       | NA,NA,NA |        | LEVEL FLYOVER     | NA,NA,NA | 23,26,22  | NA,NA,24 |       |        |      |
| TAKEOFF                      | NA,NA,NA  |        | 22,34,26 |       | 22,24,34 |        | TAKEOFF           | NA,NA,NA | 22,34,35  | 24,22,24 |       |        |      |
| <b>STATIC FLIGHT IDLE</b>    |           |        |          |       |          |        |                   |          |           |          |       |        |      |
| 0                            | 45        | 90     | 135      | 180   | 225      | 270    | 315               | 0        | 45        | 90       | 135   | 180    |      |
| HARD PI-1                    | 61.2      | 67.0   | 69.7     | 66.0  | 69.7     | 73.6   | 71.9              | 71.3     |           |          | 225   | 270    | 315  |
|                              |           |        |          |       |          |        |                   |          | HARD PI-2 | 69.3     | 68.5  | 72.0   | 72.2 |
|                              |           |        |          |       |          |        |                   |          |           | 72.1     | 73.4  | 72.8   | 69.5 |

DATA CAME FROM THE APRIL 1986 & SEPTEMBER 1986 SUBMITTALS.

# Table 5.5.C

CANADA FINAL CORRECTED DATA

|                              | PILOT 2-1  |        |            |       |            |      | PILOT 2-2             |            |       |            |       |            | STD<br>DEV | 90% CI     |
|------------------------------|------------|--------|------------|-------|------------|------|-----------------------|------------|-------|------------|-------|------------|------------|------------|
|                              | LEFT       | CENTER | RIGHT      | CMIC  | STD        | DEV  | LEFT                  | CENTER     | RIGHT | CMIC       | STD   | DEV        |            |            |
| <b>APPROACH</b>              |            |        |            |       |            |      |                       |            |       |            |       |            |            |            |
| EPNL                         | 87.27      | 83.38  | 91.77      | 90.81 | 0.61       | 1.03 | EPNL                  | NA         | NA    | NA         | NA    | NA         | NA         | NA         |
| PNLT <sup>m</sup>            | 86.78      | 85.26  | 91.54      | 91.39 | 0.28       | 0.40 | PNLT <sup>m</sup>     | NA         | NA    | NA         | NA    | NA         | NA         | NA         |
| ALM                          | 71.76      | 83.52  | 77.65      | 77.64 | 0.47       | 0.79 | ALM                   | NA         | NA    | NA         | NA    | NA         | NA         | NA         |
| SEL                          | 82.76      | 80.80  | 82.36      | 87.31 | 0.50       | 0.84 | SEL                   | NA         | NA    | NA         | NA    | NA         | NA         | NA         |
| <b>LEVEL FLYOVER</b>         |            |        |            |       |            |      |                       |            |       |            |       |            |            |            |
| EPNL                         | 87.61      | 88.77  | 88.12      | 88.16 | 0.46       | 1.06 | LEVEL FLYOVER         | NA         | NA    | NA         | NA    | NA         | NA         | NA         |
| PNLT <sup>m</sup>            | 88.17      | 81.41  | 88.25      | 89.28 | 0.47       | 2.09 | EPNL                  | 89.42      | 88.58 | 88.94      | 88.96 | 0.43       | 0.51       |            |
| ALM                          | 74.02      | 77.24  | 77.71      | 74.99 | 0.14       | 0.61 | PNLT <sup>m</sup>     | 91.49      | 91.46 | 89.69      | 90.87 | 0.80       | 0.94       |            |
| SEL                          | 83.68      | 85.41  | 83.77      | 84.26 | 0.44       | 1.95 | ALM                   | 76.16      | 77.34 | 74.83      | 76.11 | 0.97       | 1.10       |            |
| <b>TAKEOFF</b>               |            |        |            |       |            |      |                       |            |       |            |       |            |            |            |
| EPNL                         | 87.79      | 88.16  | 86.03      | 87.03 | 0.85       | 1.45 | TAKEOFF               | NA         | NA    | NA         | NA    | NA         | NA         | NA         |
| PNLT <sup>m</sup>            | 88.68      | 89.99  | 87.44      | 88.71 | 0.79       | 1.34 | EPNL                  | 86.76      | 89.35 | 87.65      | 87.95 | 0.92       | 1.56       |            |
| ALM                          | 72.74      | 75.74  | 71.56      | 73.21 | 0.82       | 1.38 | PNLT <sup>m</sup>     | 86.85      | 90.82 | 89.08      | 88.92 | 1.37       | 2.31       |            |
| SEL                          | 83.28      | 84.63  | 81.84      | 83.25 | 0.91       | 1.52 | ALM                   | 71.29      | 75.99 | 72.94      | 73.41 | 1.29       | 2.17       |            |
| <b>DURATION P</b>            |            |        |            |       |            |      |                       |            |       |            |       |            |            |            |
| APPROACH                     | 20.50      | 15.70  | 21.20      |       |            |      | DURATION P            | NA         | NA    | NA         | NA    | NA         | NA         | NA         |
| LEVEL FLYOVER                | 20.60      | 11.60  | 19.80      |       |            |      | APPROACH              | NA         | NA    | NA         | NA    | NA         | NA         | NA         |
| TAKEOFF                      | 24.60      | 16.70  | 25.70      |       |            |      | LEVEL FLYOVER         | 20.70      | 14.40 | 17.60      |       |            |            |            |
| <b>DURATION A</b>            |            |        |            |       |            |      |                       |            |       |            |       |            |            |            |
| APPROACH                     | 22.60      | 14.70  | 21.90      |       |            |      | DURATION A            | NA         | NA    | NA         | NA    | NA         | NA         | NA         |
| LEVEL FLYOVER                | 22.60      | 17.00  | 17.10      |       |            |      | APPROACH              | NA         | NA    | NA         | NA    | NA         | NA         | NA         |
| TAKEOFF                      | 25.60      | 20.00  | 28.40      |       |            |      | LEVEL FLYOVER         | 20.20      | 13.70 | 17.60      |       |            |            |            |
| <b>TONE CORRECTION VALUE</b> |            |        |            |       |            |      |                       |            |       |            |       |            |            |            |
| APPROACH                     | 1.20       | 1.10   | 1.50       |       |            |      | TONE CORRECTION VALUE | NA         | NA    | NA         | NA    | NA         | NA         | NA         |
| LEVEL FLYOVER                | 1.55       | 1.10   | 1.18       |       |            |      | APPROACH              | NA         | NA    | NA         | NA    | NA         | NA         | NA         |
| TAKEOFF                      | 2.87       | 2.20   | 3.40       |       |            |      | LEVEL FLYOVER         | 1.54       | 1.30  | 1.36       |       |            |            |            |
| <b>TONE CORRECTION BAND</b>  |            |        |            |       |            |      |                       |            |       |            |       |            |            |            |
| APPROACH                     | NA         | 25     | 27         |       |            |      | TONE CORRECTION BAND  | NA         | NA    | NA         | NA    | NA         | NA         | NA         |
| LEVEL FLYOVER                | NA         | 27     | NA         |       |            |      | APPROACH              | NA         | NA    | NA         | NA    | NA         | NA         | NA         |
| TAKEOFF                      | NA         | 21     | 22         |       |            |      | LEVEL FLYOVER         | NA         | 27    | NA         | NA    | NA         | NA         | NA         |
| <b>MAX NOV BANDS</b>         |            |        |            |       |            |      |                       |            |       |            |       |            |            |            |
| APPROACH                     | NA, NA, NA |        | 25, 26, 27 |       | 27, 22, NA |      | MAX NOV BANDS         | NA, NA, NA |       | NA, NA, NA |       | NA, NA, NA |            | NA, NA, NA |
| LEVEL FLYOVER                | NA, NA, NA |        | 23, 25, 27 |       | NA, NA, 34 |      | APPROACH              | NA, NA, NA |       | 27, 26, 27 |       | 23, 24, NA |            | NA, NA, NA |
| TAKEOFF                      | NA, NA, NA |        | 22, 24, 25 |       | 24, 22, 24 |      | LEVEL FLYOVER         | NA, NA, NA |       | 22, 24, 25 |       | 24, 22, 24 |            | NA, NA, NA |

DATA CAME FROM THE APRIL 1984 & SEPTEMBER 1986 SUBMISSIONS.

**Table 5.5.D**  
UNITED STATES FINAL CORRECTED DATA

| PILOT 1-1                    |          |        |          |       |          |        |      | PILOT 1-2         |          |       |          |       |          |      |  |
|------------------------------|----------|--------|----------|-------|----------|--------|------|-------------------|----------|-------|----------|-------|----------|------|--|
|                              | STD      |        |          |       |          |        |      |                   | STD      |       |          |       |          |      |  |
|                              | LEFT     | CENTER | RIGHT    | SMIC  | DEV      | 90% CI |      | LEFT              | CENTER   | RIGHT | SMIC     | DEV   | 90% CI   |      |  |
| <b>APPROACH</b>              |          |        |          |       |          |        |      |                   |          |       |          |       |          |      |  |
| EPNL                         | 87.30    | 92.50  | 91.00    | 90.20 | 0.55     | 0.40   |      | EPNL              | 86.90    | 92.70 | 90.40    | 90.00 | 0.41     | 0.39 |  |
| PNL <sub>Tm</sub>            | 86.90    | 94.10  | 90.90    | 90.60 | 0.37     | 0.58   |      | PNL <sub>Tm</sub> | 86.30    | 94.00 | 90.20    | 90.20 | 0.38     | 0.36 |  |
| ALM                          | 72.50    | 81.70  | 77.60    | 77.30 | 0.82     | 0.55   |      | ALM               | 72.20    | 81.50 | 76.80    | 76.80 | 0.49     | 0.46 |  |
| SEL                          | 83.40    | 89.70  | 88.20    | 87.10 | 0.53     | 0.35   |      | SEL               | 83.60    | 90.10 | 87.70    | 87.10 | 0.36     | 0.34 |  |
| <b>LEVEL FLYOVER</b>         |          |        |          |       |          |        |      |                   |          |       |          |       |          |      |  |
| EPNL                         | 87.30    | 85.30  | 86.30    | 86.80 | 0.29     | 0.21   |      | EPNL              | 87.70    | 87.70 | 85.30    | 87.20 | 0.15     | 0.19 |  |
| PNL <sub>Tm</sub>            | 86.00    | 89.10  | 87.30    | 88.10 | 0.27     | 0.20   |      | PNL <sub>Tm</sub> | 89.70    | 90.30 | 87.80    | 89.70 | 0.14     | 0.16 |  |
| ALM                          | 73.90    | 75.60  | 73.90    | 74.50 | 0.26     | 0.19   |      | ALM               | 75.30    | 76.80 | 74.70    | 75.60 | 0.17     | 0.20 |  |
| SEL                          | 83.30    | 83.60  | 82.90    | 83.40 | 0.23     | 0.17   |      | SEL               | 84.00    | 84.30 | 83.10    | 83.80 | 0.23     | 0.27 |  |
| <b>TAKEOFF</b>               |          |        |          |       |          |        |      |                   |          |       |          |       |          |      |  |
| EPNL                         | 86.90    | 86.70  | 86.20    | 86.60 | 0.31     | 0.21   |      | EPNL              | 87.40    | 86.40 | 85.90    | 86.60 | 0.25     | 0.23 |  |
| PNL <sub>Tm</sub>            | 87.30    | 88.30  | 87.50    | 87.90 | 0.55     | 0.37   |      | PNL <sub>Tm</sub> | 88.70    | 87.70 | 87.20    | 87.90 | 0.18     | 0.17 |  |
| ALM                          | 73.10    | 73.50  | 71.80    | 72.90 | 0.45     | 0.30   |      | ALM               | 73.40    | 73.10 | 71.70    | 72.70 | 0.43     | 0.41 |  |
| SEL                          | 83.40    | 82.80  | 82.60    | 82.90 | 0.25     | 0.17   |      | SEL               | 83.70    | 82.90 | 82.40    | 83.00 | 0.24     | 0.23 |  |
| <b>DURATION P</b>            |          |        |          |       |          |        |      |                   |          |       |          |       |          |      |  |
| APPROACH                     | 32.10    | 17.10  | 25.30    |       |          |        |      | APPROACH          | 27.00    | 18.00 | 24.60    |       |          |      |  |
| LEVEL FLYOVER                | 20.00    | 12.50  | 16.90    |       |          |        |      | LEVEL FLYOVER     | 17.30    | 11.70 | 16.60    |       |          |      |  |
| TAKEOFF                      | 20.90    | 16.00  | 21.50    |       |          |        |      | TAKEOFF           | 19.50    | 18.10 | 22.10    |       |          |      |  |
| <b>DURATION A</b>            |          |        |          |       |          |        |      |                   |          |       |          |       |          |      |  |
| APPROACH                     | 33.40    | 17.00  | 26.80    |       |          |        |      | APPROACH          | 34.20    | 18.80 | 26.70    |       |          |      |  |
| LEVEL FLYOVER                | 21.70    | 13.70  | 17.10    |       |          |        |      | LEVEL FLYOVER     | 18.80    | 12.60 | 15.00    |       |          |      |  |
| TAKEOFF                      | 24.10    | 19.70  | 25.90    |       |          |        |      | TAKEOFF           | 29.60    | 25.70 | 26.40    |       |          |      |  |
| <b>TONE CORRECTION VALUE</b> |          |        |          |       |          |        |      |                   |          |       |          |       |          |      |  |
| APPROACH                     | 1.50     | 1.00   | 1.50     |       |          |        |      | APPROACH          | 1.20     | 0.80  | 1.30     |       |          |      |  |
| LEVEL FLYOVER                | 1.70     | 1.10   | 1.30     |       |          |        |      | LEVEL FLYOVER     | 1.50     | 1.20  | 0.90     |       |          |      |  |
| TAKEOFF                      | 2.80     | 2.10   | 2.50     |       |          |        |      | TAKEOFF           | 2.70     | 2.10  | 2.50     |       |          |      |  |
| <b>TONE CORRECTION BAND</b>  |          |        |          |       |          |        |      |                   |          |       |          |       |          |      |  |
| APPROACH                     | 27       | 25     | 27       |       |          |        |      | APPROACH          |          | 15    | 27       |       |          |      |  |
| LEVEL FLYOVER                | 20       | 22     | 22       |       |          |        |      | LEVEL FLYOVER     |          | 22    | 22       |       |          |      |  |
| TAKEOFF                      | 22       | 22     | 22       |       |          |        |      | TAKEOFF           |          | 22    | 22       |       |          |      |  |
| <b>MAX NOY BANDS</b>         |          |        |          |       |          |        |      |                   |          |       |          |       |          |      |  |
| APPROACH                     | 27,24,25 |        | 25,25,23 |       | 24,27,NA |        |      | APPROACH          | 29,24,24 |       | 25,NA,25 |       | 24,27,26 |      |  |
| LEVEL FLYOVER                | 27,22,22 |        | 23,26,27 |       | 24,24,25 |        |      | LEVEL FLYOVER     | 27,24,23 |       | 27,26,27 |       | 24,25,NA |      |  |
| TAKEOFF                      | 21,24,22 |        | 22,25,24 |       | 24,22,24 |        |      | TAKEOFF           | 21,24,24 |       | 22,25,24 |       | 24,22,24 |      |  |
| <b>STATIC DATA</b>           |          |        |          |       |          |        |      |                   |          |       |          |       |          |      |  |
| HARD                         | 0        | 45     | 90       | 105   | 120      | 125    | 270  | 315               |          |       |          |       |          |      |  |
|                              | -11.9    | 71.2   | 71.7     | 74.1  | 72.8     | 66.5   | 70.6 | 69.0              |          |       |          |       |          |      |  |
| SOFT                         | 52.2     | 62.5   | 63.6     | 60.9  | 62.0     | 63.0   | 64.5 | 61.0              |          |       |          |       |          |      |  |
|                              | -55.5    | 64.5   | 65.6     | 62.9  | 62.5     | 61.9   | 62.5 | 61.5              |          |       |          |       |          |      |  |

**Table 5.5.E**  
UNITED STATES FINAL CORRECTED DATA

| PILOT 2-1                    |          |          |          |       |      |        | PILOT 2-2                   |          |          |          |       |      |        |
|------------------------------|----------|----------|----------|-------|------|--------|-----------------------------|----------|----------|----------|-------|------|--------|
|                              | STD      |          |          |       |      |        |                             | STD      |          |          |       |      |        |
|                              | LEFT     | CENTER   | RIGHT    | 3MIC  | DEV  | 90% CI |                             | LEFT     | CENTER   | RIGHT    | 3MIC  | DEV  | 90% CI |
| <b>APPROACH</b>              |          |          |          |       |      |        | <b>APPROACH</b>             |          |          |          |       |      |        |
| EPNL                         | 86.40    | 92.40    | 90.80    | 90.10 | 0.71 | 0.52   | EPNL                        | 87.10    | 91.80    | 91.40    | 90.50 | 0.52 | 0.75   |
| PNLT <sub>m</sub>            | 86.30    | 94.50    | 91.10    | 90.80 | 0.58 | 0.42   | PNLT <sub>m</sub>           | 86.70    | 94.20    | 92.00    | 91.50 | 0.47 | 0.26   |
| AL <sub>m</sub>              | 71.60    | 81.90    | 78.10    | 77.30 | 0.54 | 0.40   | AL <sub>m</sub>             | 72.60    | 81.60    | 76.40    | 77.50 | 0.58 | 0.36   |
| SEL                          | 82.80    | 89.70    | 88.20    | 87.10 | 0.63 | 0.46   | SEL                         | 83.70    | 90.00    | 88.50    | 87.40 | 0.44 | 0.27   |
| <b>LEVEL FLYOVER</b>         |          |          |          |       |      |        | <b>LEVEL FLYOVER</b>        |          |          |          |       |      |        |
| EPNL                         | 87.30    | 87.50    | 86.20    | 87.00 | 0.30 | 0.25   | EPNL                        | 88.60    | 87.00    | 87.30    | 87.60 | 0.45 | 0.30   |
| PNLT <sub>m</sub>            | 89.00    | 89.90    | 87.80    | 88.90 | 0.23 | 0.19   | PNLT <sub>m</sub>           | 90.50    | 89.70    | 88.80    | 89.70 | 0.46 | 0.29   |
| AL <sub>m</sub>              | 74.80    | 76.40    | 74.50    | 75.20 | 0.36 | 0.30   | AL <sub>m</sub>             | 76.20    | 79.10    | 75.50    | 75.90 | 0.59 | 0.36   |
| SEL                          | 83.90    | 84.20    | 83.10    | 83.70 | 0.27 | 0.22   | SEL                         | 85.00    | 83.60    | 82.90    | 84.10 | 0.43 | 0.27   |
| <b>TAKEOFF</b>               |          |          |          |       |      |        | <b>TAKEOFF</b>              |          |          |          |       |      |        |
| EPNL                         | 87.30    | 87.70    | 86.50    | 87.20 | 0.59 | 0.44   | EPNL                        | 89.00    | 89.40    | 87.30    | 88.60 | 0.63 | 0.52   |
| PNLT <sub>m</sub>            | 89.70    | 89.10    | 88.20    | 88.70 | 0.49 | 0.36   | PNLT <sub>m</sub>           | 90.20    | 90.70    | 89.30    | 90.10 | 0.36 | 0.71   |
| AL <sub>m</sub>              | 73.40    | 74.50    | 72.70    | 73.60 | 0.62 | 0.45   | AL <sub>m</sub>             | 74.80    | 76.20    | 73.70    | 74.90 | 0.73 | 0.60   |
| SEL                          | 83.40    | 84.10    | 82.80    | 83.40 | 0.65 | 0.48   | SEL                         | 84.80    | 85.80    | 83.50    | 84.80 | 0.58 | 0.43   |
| <b>DURATION P</b>            |          |          |          |       |      |        | <b>DURATION P</b>           |          |          |          |       |      |        |
| APPROACH                     | 28.30    | 14.10    | 22.70    |       |      |        | APPROACH                    | 27.60    | 15.00    | 20.80    |       |      |        |
| LEVEL FLYOVER                | 16.50    | 12.90    | 16.20    |       |      |        | LEVEL FLYOVER               | 16.90    | 12.60    | 19.70    |       |      |        |
| TAKEOFF                      | 21.10    | 17.60    | 21.90    |       |      |        | TAKEOFF                     | 19.60    | 16.80    | 18.70    |       |      |        |
| <b>DURATION A</b>            |          |          |          |       |      |        | <b>DURATION A</b>           |          |          |          |       |      |        |
| APPROACH                     | 34.60    | 14.40    | 24.20    |       |      |        | APPROACH                    | 34.80    | 15.70    | 22.70    |       |      |        |
| LEVEL FLYOVER                | 18.80    | 13.90    | 16.80    |       |      |        | LEVEL FLYOVER               | 19.10    | 13.40    | 18.40    |       |      |        |
| TAKEOFF                      | 25.90    | 20.50    | 26.00    |       |      |        | TAKEOFF                     | 24.00    | 19.90    | 23.20    |       |      |        |
| <b>TONE CORRECTION VALUE</b> |          |          |          |       |      |        | <b>TONE CORRECTION</b>      |          |          |          |       |      |        |
| APPROACH                     | 1.40     | 0.90     | 1.80     |       |      |        | APPROACH                    | 1.40     | 0.80     | 1.80     |       |      |        |
| LEVEL FLYOVER                | 1.90     | 1.10     | 1.20     |       |      |        | LEVEL FLYOVER               | 1.70     | 1.20     | 1.20     |       |      |        |
| TAKEOFF                      | 2.70     | 2.00     | 2.60     |       |      |        | TAKEOFF                     | 2.70     | 2.00     | 2.40     |       |      |        |
| <b>TONE CORRECTION BAND</b>  |          |          |          |       |      |        | <b>TONE CORRECTION BAND</b> |          |          |          |       |      |        |
| APPROACH                     | 27       | 25       | 27       |       |      |        | APPROACH                    | 27       | 27       | 27       |       |      |        |
| LEVEL FLYOVER                | 22       | 23       | 22       |       |      |        | LEVEL FLYOVER               | 22       | 23       | 22       |       |      |        |
| TAKEOFF                      | 22       | 19       | 22       |       |      |        | TAKEOFF                     | 22       | 22       | 22       |       |      |        |
| <b>MAX NOY BANDS</b>         |          |          |          |       |      |        | <b>MAX NOY BANDS</b>        |          |          |          |       |      |        |
| APPROACH                     | 23,24,NA | 25,24,26 | 24,27,27 |       |      |        | APPROACH                    | 23,24,25 | 25,27,26 | 24,27,23 |       |      |        |
| LEVEL FLYOVER                | 23,NA,33 | 23,26,27 | 24,27,26 |       |      |        | LEVEL FLYOVER               | 23,33,22 | 23,26,27 | 23,34,NA |       |      |        |
| TAKEOFF                      | 22,24,34 | 22,35,34 | 24,22,26 |       |      |        | TAKEOFF                     | 22,24,34 | 22,35,34 | 24,22,34 |       |      |        |

## 6.0 THE HNMRP AND THE AMENDMENTS TO THE NOISE CERTIFICATION STANDARD

The proposed amendments to the existing ICAO Annex 16, Chapter 8 and Appendix 4 requirements (ratified at CAEP/1) are outlined below in Section 6.1. The CAEP ratified amendments will be forwarded "as advice from a committee of experts" to the ICAO Council for action. The time-frame for the ICAO Council approval process historically has been 18 months to two years after committee ratification. Subsequent to their approval these amendments will officially be incorporated into Annex 16.

The HNMRP played an active role in the development of each of these amendments/refinements. A detailed discussion of each issue is provided in Sections 6.2--Takeoff Issues, 6.3--Level Flyover Issues, 6.4--Approach Issues, and 6.5--Other Issues.

### 6.1 SUMMARY OF THE RATIFIED PROPOSED AMENDMENTS

#### 6.1.1 Takeoff Operation Amendments

- Clarify the takeoff reference procedure
- Designate takeoff power as requiring minimum specification engine power
- Modify the takeoff profile
- Limit data adjustment requirements on takeoff to a total of 2dB for distance related deviations from the reference path

In addition to the above, the group agreed to study the feasibility of modifications to takeoff requirements in the future.

#### 6.1.2 Level Flyover Operation Amendments

- Establish a clear definition of the level flyover test speed for certification purposes
- Establish RPM test window
- Refine the source noise adjustment requirement

A great deal of time was also devoted to discussing the standardization of reference temperatures for the level flyover operation.

#### 6.1.3 Approach Operation Issues

- Establish test window

CAEP/1 also recommended as a future work topic: the "completion of a study on the issue of speed control on approach."

#### 6.1.4 Other Amendments

- Establish a more rigorous detector dynamic response criteria for representing SLOW response by incorporating "4-Gates" in

- the detector onset criteria curve
- Incorporate a note to discourage further use of older technology noise analyzers with comparatively slow sampling rates, which yield higher noise levels
  - Eliminate the "no correction window"
  - Establish test windows (previously included in the "no correction window")
  - Establish a requirement to quantify and limit, within reason, the deviation in the sideline elevation angle Psi
  - Incorporate a provision to allow more extensive use of sensitivity curves in implementing data adjustments.

CAEP/1 also recommended continuation of helicopter technical work by Working Group II.

## 6.2 TAKEOFF OPERATION ISSUES

### 6.2.1 Takeoff Reference Procedure

To clarify the definition of the reference takeoff flight path (presented in ICAO Annex 16, Chapter 8, Section 8.6.2.1.a and 8.6.2.1.f) it was agreed that the first segment--level flight path, and the second segment--takeoff climb, should be represented as two straight lines intersecting 500 meters prior to the takeoff measurement point. It was also noted that the best rate of climb (BRC) and the speed for best rate of climb ( $V_y$ ) should be certificated values based on a minimum performance scenario (i.e., variable torque engine, hot-day cooling requirements, etc.).

The CAEP/1 Chapter 8, Section 8.6.2.1 ratified amendments are as follows:

- a) the helicopter shall be stabilized at the maximum takeoff power corresponding to minimum installed engine(s) specification power available for the reference ambient conditions or gearbox torque limit, whichever is lower, and along a path starting from a point located 500 m (1640 ft) prior to the flight path reference point, at 20 m (65 ft) above the ground.
- f) the reference takeoff path is defined as a straight line segment inclined from the starting point (500 m prior to the center microphone location and 20 m above ground level) at an angle defined by Best Rate of Climb (BRC) and  $V_y$  for minimum specification engine performance.

### 6.2.2 Takeoff Power

Revision of the takeoff procedure, to specify the use of minimum specification takeoff power, was an issue raised during the HNMRP. As stated in PC Paper #5 (Ref. 12), presented at the Paris HNMRP meeting:

This revision should achieve a greater consistency in "test results for rotorcraft of the same design type tested with different engines at different ambient conditions. The minimum specification torque available at a specified ambient condition is a known power that will not be affected by engine condition or actual ambient condition. If the reference power condition is stated as maximum takeoff power or maximum continuous power, the actual power of use may vary by as much as 20 percent between two helicopters of the same design type tested at different ambient conditions. Such variation in power available used for testing and resulting variation in test day airspeeds and rates of climb could result in a particular type design showing compliance with noise requirements in one country, but not in others."

At CAEP/1 takeoff power was defined as requiring minimum specification engine power. Chapter 8, Section 8.6.2.1.a) was revised as noted above in Section 6.2.1.

### 6.2.3 Takeoff Procedures

During the HNMRP, a new method of performing the takeoff operation was proposed which would link noise test requirements more closely with takeoff airworthiness requirements. This proposed method is in contrast to the current takeoff requirements, which are linked with en-route climb performance airworthiness certification requirements.

The following discussion and recommendation were abstracted from a paper (Ref. 13) prepared by US FAA helicopter airworthiness expert Larry Plaster (a technical advisor to the HNMRP Program Coordinator). The paper delineated the reasons for considering the proposed regulatory refinements.

"1. The current Annex 16, Chapter 8, takeoff performance requirements are linked to the airworthiness en-route climb-out performance demonstration. These airworthiness tests establish  $V_y$  and the best rate of climb.

"There exists another set of airworthiness testing requirements pertaining to takeoff and landing. These requirements quantify (and certificate) different performance characteristics.

This "second set of performance requirements may be a better, or more representative set of airworthiness requirements to utilize as the basis for the takeoff noise certification test.

"2. An abrupt or rapid application of takeoff power at the 500 meter point (rotation point) may result in an excessive nose-down attitude for some higher powered models. This problem (would) be avoided by a scheme using a takeoff power defined as hover power plus some percentile as expressed in the takeoff demonstration airworthiness requirement....

"Newer multi-engine helicopter designs such as the Bell 412, Bell 214ST, and Sikorsky S-76B cannot apply full takeoff power during the

acceleration without achieving excessive nose down pitch attitudes to remain outside the height-velocity (H-V) diagram. To eliminate this problem, manufacturers have been limiting the maximum power that can be used for takeoff to the power required to hover in-ground-effect (HIGE) plus a delta percent torque maximum that may be added to the required hover for takeoff acceleration for takeoff acceleration. (For example, the Bell 214ST uses HIGE hover power plus 10 percent torque maximum for takeoff.) Therefore, the power actually being used for takeoff is significantly less than rated takeoff which is approved for use based on structural and drive system considerations. However, the current noise regulation specifies the use of maximum takeoff power which has historically been interpreted as the drive system rated takeoff power and not the takeoff power used to establish takeoff distances for airworthiness certification.

"An additional factor which contributes to the current takeoff reference profile not being representative of actual takeoff procedures is the requirement to use  $V_y$  airspeed. Transport category helicopters establish a takeoff safety speed ( $V_{toss}$ ), for Category A takeoff performance and/or a takeoff climb out speed ( $V_{tocs}$ ), for Category B takeoff performance. The rotorcraft Flight Manual (RFM) takeoff performance distances are based on the use of these reference speeds not  $V_y$ .  $V_{toss}$  and  $V_{tocs}$  are typically 15 to 20 knots less than  $V_y$ .

"The combination of the two factors described above result in the actual takeoff profile for helicopters in this category being much shallower than the profile currently being used as a takeoff reference.

"Recommendation: Therefore it is recommended that WG II study the practicality of a future amendment to ICAO Annex 16, Chapter 8, paragraph 8.6.2, which requires:

"1. The helicopter shall be stabilized at -

(a) For helicopters for which the determination of takeoff performance is required by airworthiness regulations, the torque used to establish the takeoff distance for sea level, 25 degrees Celsius ambient conditions;

(b) For all other helicopters, the torque corresponding to the minimum installed power available for sea level, 25 degrees Celsius ambient conditions;

and at the best rate of climb....

"2. The helicopter speed shall be maintained throughout the takeoff reference procedure at -

(a) For helicopters for which the determination of takeoff performance is required by airworthiness regulations, the speed used to establish takeoff distance for sea level, 25 degrees Celsius ambient conditions;

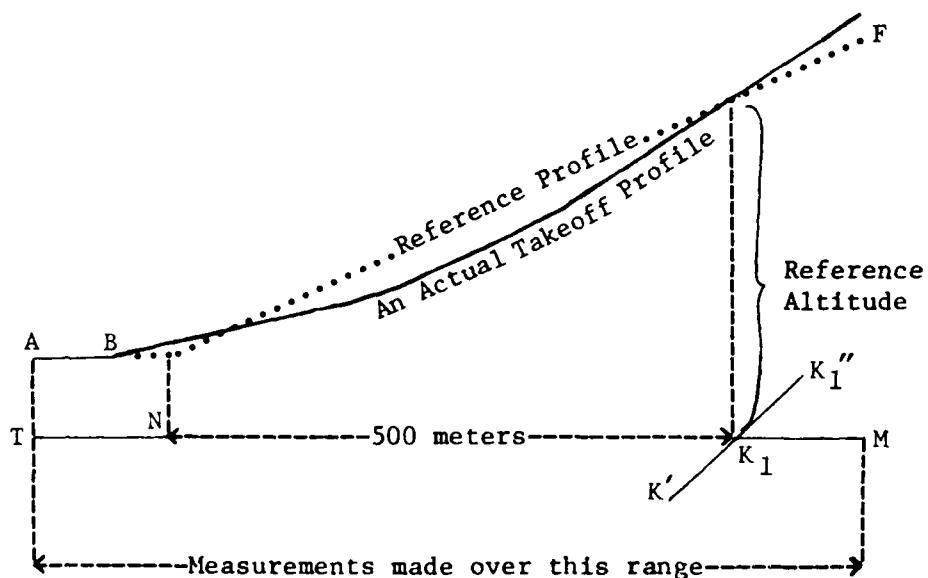
(b) For all other helicopters, the best rate of climb speed  $V_y$ , or the lowest approved speed for climb after takeoff, whichever is the greater, for sea level, 25 degrees Celsius ambient conditions.

It was agreed at CAEP/1 that this concept would be examined as part of the future WG II agenda.

#### 6.2.4 Takeoff Profile

It was recommended at the Paris HNM RP meeting that the takeoff operation diagram be modified to extend from point B along a curved path not co-linear with the reference path. The CAEP/1 ratified amendment to ICAO Annex 16, Appendix 4 is as follows:

9.2.1 Takeoff Profile Note.- Figure 4-1 illustrates the reference and a typical takeoff profile.



- a) during actual testing the helicopter is initially stabilized in level flight at the best rate of climb speed,  $V_y$ , at a point A and continues to a point B where takeoff power is applied and a steady climb is initiated. A steady climb shall be maintained throughout the 10 dB-down period and beyond to the end of the certification flight path (point F).

### 6.2.5 Implementation of the Takeoff Operation

At the Paris HNMRP meeting, it was proposed that point "B" of the reference takeoff profile above be adjustable, as required, to stay within the required reference window.

At CAEP/1 it was agreed that a new note be added to the end of Appendix 4, section 9.2.1 as follows:

Note.- The position of point B may vary within the limits allowed by the certificating authorities.

### 6.2.6 Test to Reference Position Adjustment Limitations

At the Paris meeting, there was considerable discussion concerning the issue of minimizing the adjustments from the test day takeoff flight path to the reference takeoff flight path.

The CAEP/1 ratified amendment to Chapter 8, Section 8.7.5 is as follows:

Adjustments for differences between test and reference flight procedures shall not exceed:

- a) for takeoff 4.0 EPNdB, of which the arithmetic sum of delta 1 and the term  $-7.5 \log(QK/QrKr)$  from delta 2 shall not in total exceed 2.0 EPNdB.
- b) for overflight or approach 2.0 EPNdB.

It was also suggested, at the Paris HNMRP meeting, that a follow-on study be conducted (with HNMRP data) which would develop guidance techniques for determining when the 2 dB limit window is achieved during an actual flight test.

## 6.3 LEVEL FLYOVER OPERATION ISSUES

### 6.3.1 Flyover Reference Procedure: Vh Defined

The goal of establishing a rigorous and identifiable level flyover test speed for certification purposes arose early in the HNMRP. Previously there did not exist an airworthiness referenced Vh in the Annex. The test speed was in essence established by manufacturer selection. Since VNE is often not related to overflights, it was suggested that the value Vh, maximum speed in level flight, was a more appropriate reference value to use. Difficulties were identified with the specific definition of Vh and regulatory language was suggested for the purpose of noise certification testing.

The agreed CAEP/1 proposed amendment to Chapter 8, Section 8.6.3.1 reads as follows:

Note.- For noise certification purposes,  $V_h$  is defined as the airspeed in level flight obtained using the torque corresponding to minimum installed, maximum continuous power available for sea level pressure (1013.25 hPa), 25 degree Celsius ambient conditions unless a lower airworthiness limit is imposed by the manufacturer and approved by the certificating authority.

### 6.3.2 Test Window Established

With the elimination of the old Appendix 4, Section 9.1 "no correction window," (see 6.5.3) certain operational envelopes were established as test windows, specifically allowable RPM deviation. Below is the agreed CAEP/1 proposed amendment to Chapter 8, Section 8.7.6.

During the test the average rotor rpm shall not vary from the normal maximum operating rpm by more than  $\pm 1.0$  per cent during the 10 dB-down time period.

### 6.3.3 Source Noise Adjustment

Early HNMMP evaluation of the source noise adjustment indicated that the appropriate acoustical metric for source intensity should be PNLT<sub>m</sub>, rather than EPNL as required by Annex 16 (CAN 7). The use of this metric would avoid possible confusion in adjustments related to duration effects.

HNMMP consideration of "Source Noise Correction" began at the (March 1985) Tokyo meeting with the intent of refining the CAN 7 source noise adjustment requirement to account for speed, temperature and rotor speed deviations from reference conditions. After several redrafts, the final version adopted allows the applicant the flexibility to use either advancing blade tip Mach number or another correlating parameter, whichever relates best to source noise (PNLT<sub>m</sub>).

At CAEP/1 there was still considerable debate concerning how to specify source noise correction requirements. It was acknowledged that further work was needed to understand and explain the variabilities in some of the HNMMP test results. It was also acknowledged that the blade-tip Mach number versus PNLT<sub>m</sub> relationships which were used in the repeatability tests may be improved upon. Nonetheless, many HNMMP participants found a consistent dependency between noise level and advancing blade tip Mach number.

The following is the CAEP/1 ratified amendment (Appendix 4, Section 9.5).

For overflight, if any combination of the following three factors:

- 1) airspeed deviations from reference,
- 2) rotor speed deviations from reference,
- 3) temperature deviations from reference,

result in an agreed noise correlating parameter whose value deviates from the reference value of this parameter, then source noise adjustments shall be determined from manufacturers data approved by the certificating authorities. This correction should normally be made using a sensitivity curve of PNLT M versus advancing blade tip Mach number; however, the correction may be made using an alternative parameter, or parameters, approved by the certificating authority.

Note 1.- If it is not possible to attain the reference value of advancing blade tip Mach number or the agreed reference noise correlating parameter then an extrapolation of the sensitivity curve is permitted providing that the data cover a range of noise correlating parameters agreed by the certificating authorities between test and reference conditions. The advancing blade tip Mach number or agreed noise correlating parameter shall be computed from measured data. A separate curve of source noise versus advancing blade tip Mach number or another agreed noise correlating parameter shall be derived for each of the three certification microphone locations, centerline, sideline left, and sideline right, defined relative to the direction of flight on each test run.

Note 2.- When using advancing blade tip Mach number it should be computed using true airspeed, on-board outside air temperature (OAT), and rotor speed.

CAEP/1 further agreed that research into the parameters influencing and varying helicopter noise during level overflight is an appropriate item for the future work program of the CAEP.

#### 6.3.4 Speed Duration Adjustment Through the Use of Sensitivity Curves

It was recommended at the October 1985 WG II meeting that sensitivity curves be developed to adjust for ground speed duration corrections using the same data from which source corrections were developed. The proposal essentially stated that sensitivity curves should be used when the necessary data is available, rather than using the algorithm  $10 \log V_t/V_r$  for ground speed duration correction.

This proposed amendment was eventually tabled at the Paris HNM RP meeting, but is a topic for further study.

#### 6.3.5 Level Flyover Reference Temperature

In order to achieve a consistent set of reference temperatures for all corrections and adjustments (including reference performance, source noise corrections and atmospheric absorption), it was recommended (during the Washington HNM RP meeting) that a 15 degree Celsius temperature be adopted for all applications.

At the Paris HNM RP meeting, after much discussion, this proposal was reversed in favor of retaining the 25 degree Celsius as the reference

temperature for certification testing applicable to the level flyover operation.

The current set of reference temperatures is:

|                            |                   |
|----------------------------|-------------------|
| Source Noise Correction:   | 25 degree Celsius |
| Absorption Adjustments:    | 25 degree Celsius |
| Level Flyover Performance: | 25 degree Celsius |

## 6.4 APPROACH OPERATION ISSUES

### 6.4.1 Approach Window Established

As part of the decision to drop the "no correction window", certain testing envelope constraints were introduced. A limitation of  $\pm 0.5$  degrees around the six degree reference approach angle was imposed.

At CAEP/1 the following amendment was ratified as an addition to the Chapter 8, Section 8.7 test procedures.

8.7.9 During the approach noise demonstration the helicopter shall be stabilized and following a steady glide slope angle of 6 degrees  $\pm 0.5$  degrees.

### 6.4.2 Blade Slap on Approach

In discussions at the Paris HNMRP meeting, French participants cited test results which showed a greater tendency for blade slap to occur when the test speed exceeded the reference speed. It was observed that while this phenomena is surely helicopter specific, it may be appropriate to incorporate a cautionary note in an appendix of Annex 16.

While no specific amendments pertaining to approach speed were ratified at CAEP/1, it was recommended that the "completion of a study on the issue of speed control on approach" be taken up as a future work topic.

## 6.5 OTHER ISSUES

### 6.5.1 Analysis System Detector/Integrator Response Criteria

It was found during the HNMRP data evaluation that the need existed for the establishment of a more rigorous criteria defining SLOW dynamic response.

A requirement was adopted for a rigorous onset and decay performance test easily attainable by modern equipment. This requirement specifies 4 response test points rather than the two required by IEC-179.

For scenarios in which a SLOW dynamic response is simulated from discrete one-half second sound level samples, use of a finite set of retrospective weighting coefficients is mandatory.

The following proposed amendments, which address both topics, were ratified at CAEP/1.

Appendix 4, Section 3.4.1:

The requirements relating to the analysis system are those of Appendix 2, Section 3.4, except for the response characteristics which are defined in Appendix 4, 3.4.2.

Appendix 4, Section 3.4.2

For each detector/integrator, the response to a sudden onset or interruption of a constant sinusoidal signal at the respective 1/3-octave band center frequency shall be measured at sampling instants 0.5s, 1s, 1.5s and 2.0s after the onset and 0.5s and 1.0s after interruption. The rising response at 0.5s shall be  $-4 \pm 1$  dB, and at 1s  $-1.75 \pm 0.5$  dB, at 1.5s  $-1.0 \pm 0.5$  dB, and at 2s  $-0.5 \pm 0.25$ , relative to the steady-state level. The falling response shall be such that the sum of the decibel readings (below initial steady-state level) and the corresponding rising response reading is  $6.5 \pm 1$  dB, at both 0.5s and 1s and on subsequent records the sum of the onset plus decay must be greater than 7.5 decibels.

Note 1.- For analyzers with linear detection an approximation of this response would be given by:

Weighting Coefficients for Simulation of SLOW Response

|                 |                         |     |
|-----------------|-------------------------|-----|
| Current (Li)    | one-half second record: | 33% |
| Previous (Li-1) | one-half second record: | 24% |
| Second (Li-2)   | one-half second record: | 21% |
| Third (Li-3)    | one-half second record: | 17% |

$$\text{Where: } \text{SPL} = 10 \log [ (0.17 (10^{0.1Li-3}) + 0.21 (10^{0.1Li-2}) \\ + 0.24 (10^{0.1Li-1}) + 0.33 (10^{0.1Li}) ]$$

It should be noted that when this approximation is used the calibration signal should be established without this weighting.

One member suggested that the International Electrotechnical Commission (IEC) should be asked to adopt these characteristics. The proposed rewording would alter the rising response characteristics and provide two falling response requirements.

6.5.2 Dated Noise Analyzers

It was observed during the HNMMP testing that differences in the measured values on the order of 0.5 to 0.7 dB could result from differences in the response characteristics of the analysis system used. Since all of the analyzers used could meet the Annex 16, Appendix 4, Section 3.4 dynamic

response characteristics, it was agreed that the detector/integrator characteristics should be redefined to eliminate this source of variability. As such, the incorporation of a note to discourage further use of older technology noise analyzers with comparatively slow sampling rates, which yield higher noise levels, was agreed to.

The proposed amendment to Appendix 4, Section 3.4.2 below was ratified at CAEP/1.

Note 2.- Some analyzers have been shown to have signal sampling rates that are insufficiently accurate to detect signals with crest factor ratios greater than three (common to helicopter noise). Preferably such analyzers should not be used for helicopter certification. Use of analysis systems with high signal sampling rates (greater than 40 KHz) or those with analog detectors prior to digitalization at the output of each 1/3-octave filter is encouraged.

#### 6.5.3 "No Correction Window" Deleted

Discussions at the Paris HNMRP meeting focused on some structural problems within the existing Annex 16 test and no correction window requirements. These provisions specified the permissible testing envelope and certain combinations of environmental and flight conditions for which data adjustments were unnecessary.

At Paris, and subsequently at CAEP/1, there was considerable debate concerning adjustments to flight test results. The following are excerpts from the CAEP/1 report.

"Working Group II previously recommended deletion of the so-called "no correction window" which allowed completion of flight tests within certain tolerances in mass, flight path, airspeed, rotor RPM, and ambient temperature and humidity without requiring adjustment from test to reference conditions. Some members advocated retention of the "no correction window", based on their contention that sensitivity curves would otherwise have to be developed, flight time requirements for noise certification would increase appreciably, and costs would rise significantly. Other members disputed the validity of the predicted cost increases, stating that costs would only increase on the order of 5 to 10% and held that the benefits justified added costs of that magnitude.

The perspective that dominated the CAEP/1 thinking was that the "no correction window" really was in fact a set of conditions that should have been specified as test window boundaries. The sentiment was therefore to eliminate the no correction window and transfer appropriate boundary conditions to a newly established test window.

#### 6.5.4 Test Windows Established

At Paris, and again at CAEP/1, it was suggested that Chapter 8 lacked certain essential test constraints which could reduce possible sources of

variability in noise levels. After debating the issue, the Committee agreed to specify limitations on helicopter mass, flight path and rotor RPM for noise certification.

These limitations, contained in Chapter 8, Sections 8.7.6 through 8.7.10, were ratified at CAEP/1. Proposed sections 8.7.8 and 8.7.10 are described below. Sections 8.7.6 and 8.7.9 are detailed above in the level flyover and approach sections.

8.7.8 The helicopter shall fly within  $\pm 10$  degrees from the vertical above the reference track through the center reference noise measurement position throughout the 10 dB-down time period.

8.7.10 Tests shall be conducted at a helicopter mass not less than 90 per cent of the relevant maximum certificated mass and may be conducted at a mass not exceeding 105 per cent of the relevant maximum certificated mass.

#### 6.5.5 Allowable Deviation in Sideline Elevation Angle Psi

This issue essentially embraces another type of source noise correction, the change in acoustical intensity with the direction of radiation.

During discussions at the Paris HNMMP meeting, the group agreed that the noise emission directivity angle is very important and will most certainly affect final results. It was further agreed that the Paris proposed amendment to Appendix 4 (below), ratified at CAEP/1, is only a cosmetic solution and will not solve the real problem. Recognizing that the proposed amendment below does not solve the problem, it does, nevertheless, recognize officially the existence of the problem and is considered a first step toward an ultimate solution.

9.1.2 Adjustments to the measured noise data shall be made ...

9.1.2.c) the adjustment procedure described in this section shall apply to the sideline microphones in the takeoff, overflight, and approach cases. Although the noise emission is strongly dependent on the directivity pattern, variable from one helicopter type to another, the propagation angle Theta, defined in Appendix 2, 9.3.2, Figure 2.10, shall be the same for the test and reference flight paths. The elevation angle Psi shall not be constrained as in the third note of Appendix 2, 9.3.2, but must be determined and reported. The certification authority shall specify the acceptable limitations on Psi. Corrections to data obtained when these limits are exceeded shall be applied using procedures approved by the certificating authority.

As a post script on this topic, the French delegate proposed that optional sensitivity curves be developed and utilized for sideline elevation angle adjustments. It was further suggested that members experiment with techniques for acquiring the necessary information in the most efficient manner in terms of data runs and microphone location. It was hypothesized that while greater cost is involved at the onset, with future derivatives, costs will likely be recouped.

#### **6.5.6 Optional Sensitivity Curves for Adjusting Data**

Discussions at both the Washington and Paris HNMRP meetings included the topic of optional sensitivity curves as a means to implement data adjustments, rather than the current Annex 16 adjustment algorithms. The following is the proposed amendment to Appendix 4, Section 9.1.2 ratified at CAEP/1.

Note 2.- Adjustments of noise levels for test to reference conditions may be made, subject to agreement by certificating authorities, by the methods of this section. The corrections are derived from sets of curves linking the instant at which the PNLT M is emitted for each reference procedure with appropriate parameters, for example:

- a) the height, average ground speed, and advancing blade tip Mach number for flyover;
- b) the glide slope and height for approach;
- c) the height, torque, and ground speed for takeoff.

The sensitivity curves shall provide noise level variations as a function of the parameter for which a correction is necessary.

#### **6.5.7 Technical Manual**

At the Paris meeting, the HNMRP participants recommended to WG II that a Technical Manual Committee (or Technical Issue Group) be established to specifically follow up on residual issues from the HNMRP.

The "CAEP/1 Report on Agenda Item 1" (helicopters) charged CAEP with "continued evaluation of issues leading to and arising from the Helicopter Noise Measurement Repeatability Program."

## 7.0 EPNL MULTI-NATION COMPARISON DATA

This section contains EPNL multi-nation summary comparison data for the takeoff, approach and level flyover operations. A complete reporting of the multi-nation comparison data can be found in Appendix A. The information contained in this section and in Appendix A provide an important investigative tool for the exploration of why differences exist in reported data. These data, along with the potential future analyses outlined in at the end of this report, represent the primary research instruments for HNMRP follow-on Working Group II (1987-1990) activities designed to further explore questions concerning helicopter noise certification repeatability.

Please note that all UK level flyover data was corrected with a delta 3 correction referenced to 15 degrees C. All other teams used delta 3 corrections referenced to 25 degrees C.

MULTI-NATION COMPARISON ANALYSIS  
TAKE-OFF EPNL DATA EXPRESSED IN DECIBELS (dB)

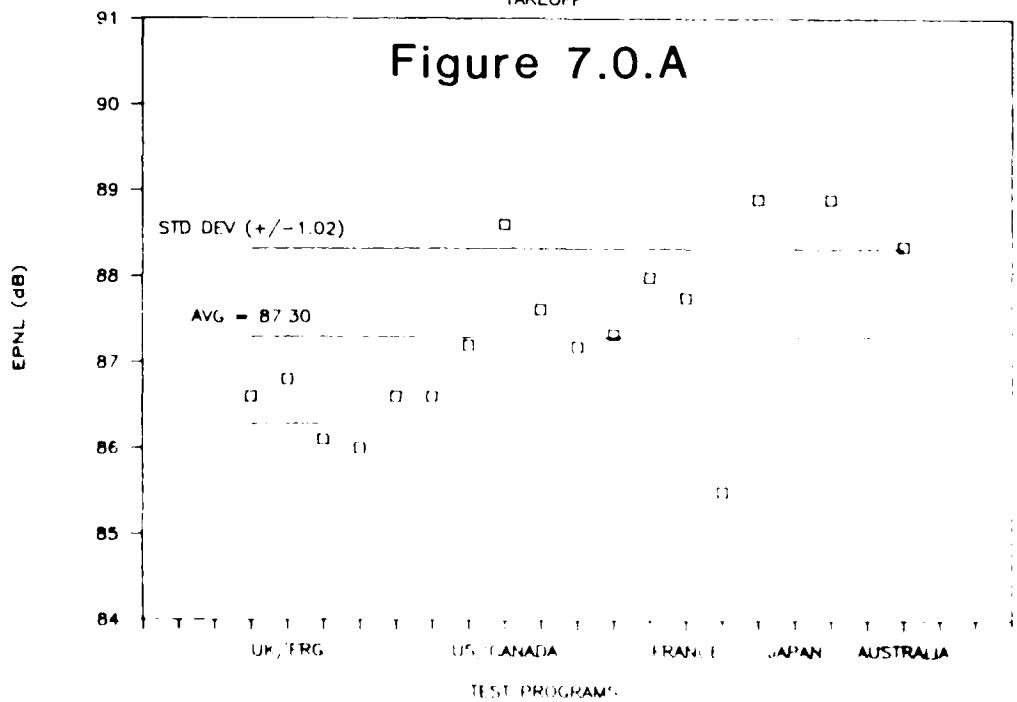
Table 7.0.A

| PARTICIPANT      | LEFT<br>SIDELINE<br>AVERAGE | CENTER LINE<br>CENTER<br>AVERAGE | RIGHT<br>SIDELINE<br>AVERAGE | 3 MIC<br>AVERAGE | STD<br>DEV | 90% C.I. | TEAM<br>AVERAGE | TEST<br>AVERAGE |
|------------------|-----------------------------|----------------------------------|------------------------------|------------------|------------|----------|-----------------|-----------------|
|                  |                             |                                  |                              |                  |            |          |                 |                 |
| AUSTRALIA        | 87.89                       | 89.55                            | 87.63                        | 88.35            | 0.39       | 0.17     | 88.35           | 88.35           |
| JAPAN-PILOT 1    | 88.80                       | 88.90                            | 88.90                        | 88.90            | 0.30       | 0.20     | 88.90           | 88.90           |
| JAPAN-PILOT 2    | 88.10                       | 90.00                            | 88.70                        | 88.90            | 0.50       | 0.30     |                 |                 |
| FRANCE-AERO      | 85.70                       | 88.40                            | 87.40                        | 87.20            | 0.64       | 0.53     | 87.20           | 86.35           |
| FRANCE-STNA      | 84.70                       | 87.30                            | 84.50                        | 85.50            | 0.40       | 0.30     | 85.50           |                 |
| ITALY            | NA                          | NA                               | NA                           | NA               | NA         | NA       |                 |                 |
| FRG-PILOT 1      | 85.50                       | 86.60                            | 86.10                        | 86.10            | 0.30       | 0.30     | 86.05           | 86.38           |
| FRG-PILOT 2      | 86.30                       | 85.70                            | 86.20                        | 86.00            | 0.19       | 0.00     |                 |                 |
| UK-PILOT 1       | 86.00                       | 87.30                            | 86.60                        | 86.60            | 0.40       | 0.30     | 86.70           |                 |
| UK-PILOT 2       | 86.40                       | 86.60                            | 87.20                        | 86.80            | 0.20       | 0.20     |                 |                 |
| CANADA-PILOT 1-1 | 87.76                       | 87.35                            | 87.75                        | 87.62            | 0.17       | 0.29     | 87.50           | 87.39           |
| CANADA-PILOT 1-2 | 88.54                       | 87.10                            | 85.93                        | 87.19            | 0.08       | 0.35     |                 |                 |
| CANADA-PILOT 2-1 | 87.79                       | 88.16                            | 86.03                        | 87.33            | 0.86       | 1.45     |                 |                 |
| CANADA-PILOT 2-2 | 86.96                       | 89.35                            | 87.65                        | 87.99            | 0.92       | 1.56     |                 |                 |
| US-PILOT 1-1     | 86.90                       | 86.70                            | 86.20                        | 86.60            | 0.31       | 0.21     | 87.25           |                 |
| US-PILOT 1-2     | 87.40                       | 86.40                            | 85.90                        | 86.60            | 0.25       | 0.23     |                 |                 |
| US-PILOT 2-1     | 87.30                       | 87.70                            | 86.50                        | 87.20            | 0.59       | 0.44     |                 |                 |
| US-PILOT 2-2     | 89.00                       | 89.40                            | 87.30                        | 88.60            | 0.63       | 0.52     |                 |                 |
| AVERAGE          | 87.12                       | 87.79                            | 86.85                        | 87.26            | 0.41       | 0.43     | 87.19           | 87.47           |
| STD DEV          | 1.22                        | 1.28                             | 1.11                         | 1.02             | 0.25       | 0.42     | 1.12            | 1.15            |
| 90% C.I.         | 0.77                        | 0.80                             | 0.76                         | 0.64             | 0.15       | 0.27     | 1.13            | 1.91            |

EPNL 3 MIC AVERAGE & STD DEVIATION

TAKEOFF

Figure 7.0.A



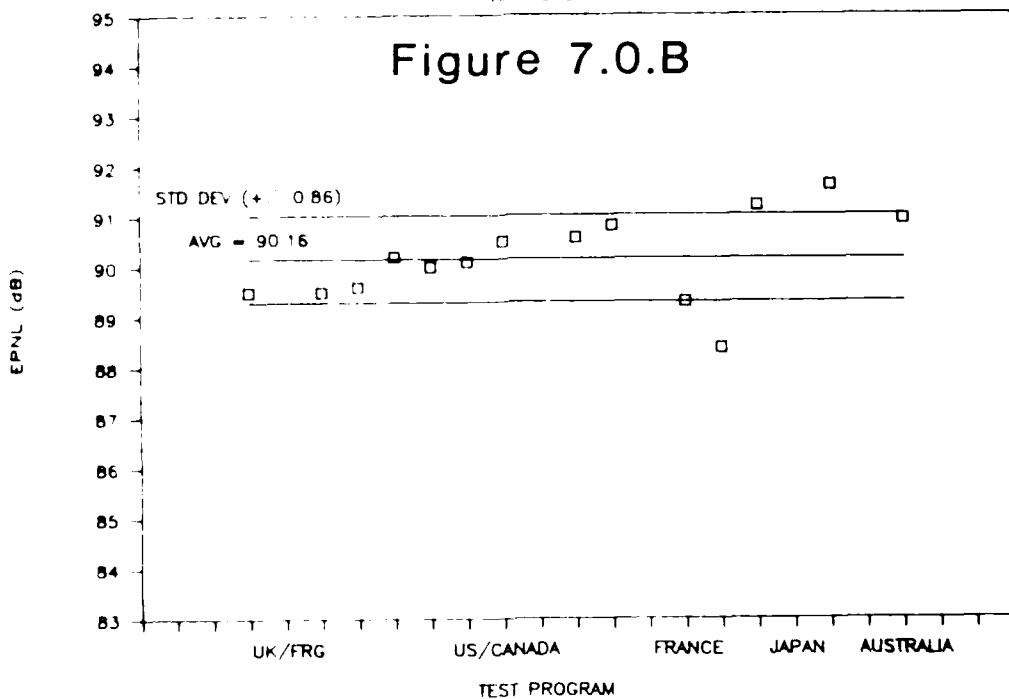
# Table 7.0.B

MULTI-NATION COMPARISON ANALYSIS  
APPROACH EPNL DATA EXPRESSED IN DECIBELS (dB)

| PARTICIPANT      | LEFT<br>SIDELINE<br>AVERAGE | CENTER LINE<br>CENTER<br>AVERAGE | RIGHT<br>SIDELINE<br>AVERAGE | 3 MIC<br>AVERAGE | STD<br>DEV | 90% C.I. | TEAM<br>AVERAGE | TEST<br>AVERAGE |
|------------------|-----------------------------|----------------------------------|------------------------------|------------------|------------|----------|-----------------|-----------------|
|                  |                             |                                  |                              |                  |            |          |                 |                 |
| AUSTRALIA        | 87.46                       | 93.82                            | 91.51                        | 90.93            | 0.98       | 0.66     | 90.93           | 90.93           |
| JAPAN-PILOT 1    | 89.30                       | 93.50                            | 90.70                        | 91.20            | 0.80       | 0.60     | 91.40           | 91.40           |
| JAPAN-PILOT 2    | 89.70                       | 93.70                            | 91.50                        | 91.60            | 0.80       | 0.50     |                 |                 |
| FRANCE-AERO      | 86.10                       | 92.30                            | 89.40                        | 89.30            | 0.84       | 1.42     | 89.30           | 88.84           |
| FRANCE-STNA      | 85.00                       | 91.40                            | 88.70                        | 88.37            | 0.50       | 0.40     | 88.37           |                 |
| ITALY            | NA                          | NA                               | NA                           | NA               | NA         | NA       |                 |                 |
| FRG-PILOT 1      | 88.90                       | 92.30                            | 89.10                        | 89.50            | 0.60       | 0.40     | 89.55           | 89.53           |
| FRG-PILOT 2      | 88.70                       | 92.60                            | 89.90                        | 89.50            | 0.50       | 0.40     |                 |                 |
| UK-PILOT 1       | 86.20                       | 92.30                            | 89.90                        | 89.50            | 0.50       | 0.40     | 89.50           |                 |
| CANADA-PILOT 1-2 | 86.97                       | 92.97                            | 91.81                        | 90.57            | 0.17       | 0.58     | 90.69           | 90.36           |
| CANADA-PILOT 2-1 | 87.27                       | 93.78                            | 91.77                        | 90.81            | 0.51       | 1.03     |                 |                 |
| US-PILOT 1-1     | 87.10                       | 92.50                            | 91.60                        | 90.20            | 0.55       | 0.40     | 90.20           |                 |
| US-PILOT 1-2     | 86.90                       | 92.70                            | 91.40                        | 90.00            | 0.41       | 0.39     |                 |                 |
| US-PILOT 2-1     | 86.40                       | 92.40                            | 90.80                        | 90.10            | 0.71       | 0.52     |                 |                 |
| US-PILOT 2-2     | 87.10                       | 92.80                            | 91.40                        | 90.50            | 0.52       | 0.35     |                 |                 |
| AVERAGE          | 87.18                       | 92.76                            | 90.56                        | 90.16            | 0.61       | 0.58     | 89.99           | 90.21           |
| STD DEV          | 0.70                        | 0.56                             | 0.77                         | 0.86             | 0.21       | 0.39     | 1.00            | 1.04            |
| 90% C.I.         | 0.86                        | 0.47                             | 0.73                         | 0.81             | 0.15       | 0.21     | 1.06            | 1.74            |

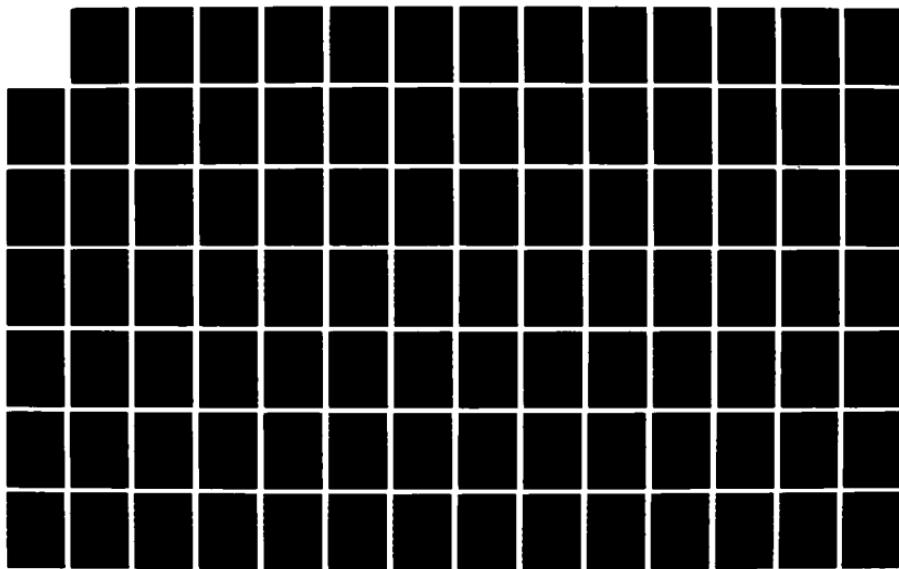
### EPNL 3 MIC AVERAGE & STD DEVIATION

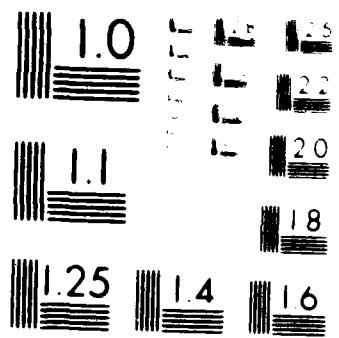
APPROACH



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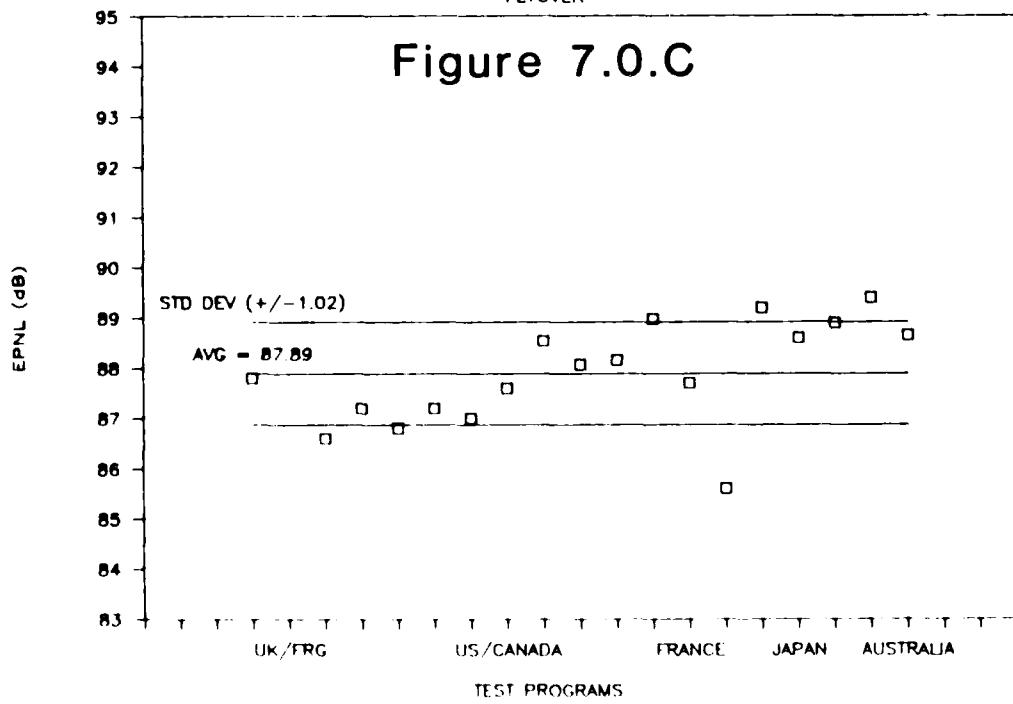
MULTI-NATION COMPARISON ANALYSIS  
LEVEL FLYOVER EPNL DATA EXPRESSED IN DECIBELS (dB)

Table 7.0.C

| PARTICIPANT      | LEFT                | CENTER LINE       | RIGHT               | UK delta 3 calculated at 15°C |            |          |                 |                 |
|------------------|---------------------|-------------------|---------------------|-------------------------------|------------|----------|-----------------|-----------------|
|                  | SIDELINE<br>AVERAGE | CENTER<br>AVERAGE | SIDELINE<br>AVERAGE | 3 MIC<br>AVERAGE              | STD<br>DEV | 90% C.I. | TEAM<br>AVERAGE | TEST<br>AVERAGE |
| AUSTRALIA        | 88.82               | 89.69             | 87.42               | 88.65                         | 0.72       | 0.39     | 88.65           | 88.65           |
| JAPAN-PILOT 1-1  | 89.10               | 89.10             | 88.40               | 89.20                         | 0.40       | 0.50     | 89.03           | 89.03           |
| JAPAN-PILOT 1-2  | 90.90               | 89.20             | 86.90               | 88.50                         | 0.40       | 0.70     |                 |                 |
| JAPAN-PILOT 2-1  | 91.40               | 90.40             | 87.90               | 88.90                         | 0.60       | 0.70     |                 |                 |
| JAPAN-PILOT 2-2  | 91.50               | 89.10             | 87.70               | 89.40                         | 0.40       | 0.50     |                 |                 |
| FRANCE-AERD      | 87.80               | 88.40             | 86.80               | 87.70                         | 0.36       | 0.43     | 87.70           | 86.65           |
| FRANCE-STNA      | 85.70               | 87.50             | 83.90               | 85.80                         | 0.40       | 0.50     | 85.60           |                 |
| ITALY            | NA                  | NA                | NA                  | NA                            | NA         | NA       | NA              |                 |
| FRG-PILOT 1-1    | 88.60               | 88.10             | 84.90               | 86.60                         | 0.30       | 0.20     | 86.90           | 87.20           |
| FRG-PILOT 1-2    | 85.70               | 89.70             | 85.60               | 87.20                         | 0.30       | 0.30     |                 |                 |
| UK PILOT 1       | 89.10               | 90.00             | 95.20               | 87.90                         | 0.25       | 0.21     | 87.80           |                 |
| CANADA-PILOT 1-1 | 88.50               | 88.67             | 88.34               | 88.54                         | 0.22       | 0.21     | 88.44           | 87.79           |
| CANADA-PILOT 1-2 | 88.55               | 88.73             | 87.29               | 88.07                         | 0.58       | 0.68     |                 |                 |
| CANADA-PILOT 2-1 | 87.61               | 88.77             | 88.12               | 88.16                         | 0.46       | 2.06     |                 |                 |
| CANADA-PILOT 2-2 | 89.42               | 88.58             | 88.94               | 88.98                         | 0.43       | 0.51     |                 |                 |
| US-PILOT 1-1     | 87.70               | 86.80             | 86.30               | 86.80                         | 0.29       | 0.21     | 87.15           |                 |
| US-PILOT 1-2     | 87.70               | 87.70             | 86.30               | 87.20                         | 0.16       | 0.19     |                 |                 |
| US PILOT 2-1     | 87.30               | 87.50             | 86.20               | 87.00                         | 0.30       | 0.25     |                 |                 |
| US-PILOT 2-2     | 88.60               | 87.00             | 87.30               | 87.60                         | 0.45       | 0.30     |                 |                 |
| AVERAGE          | 88.43               | 88.37             | 86.86               | 87.89                         | 0.39       | 0.49     | 87.66           | 87.86           |
| STD DEV          | 1.63                | 0.93              | 1.35                | 1.02                          | 0.14       | 0.43     | 1.11            | 0.99            |
| 90% C.I.         | 0.99                | 0.50              | 0.82                | 0.82                          | 0.09       | 0.26     | 1.17            | 1.65            |

EPNL 3 MIC AVERAGE & STD DEVIATION

FLYOVER





## 8.0 MULTI-NATION COMPARISON ANALYSES

Within this section a summary of the HNMRP results and findings are presented in Section 8.1 and the "Multi-Nation Comparison Analyses" are presented in Section 8.2.

### 8.1 SUMMARY OF RESULTS AND FINDINGS

#### 8.1.1 Summary of Findings

Two principle conclusions can be stated as a result of the HNMRP:

- 1) The requirements of ICAO Annex 16, Chapter 8 and Appendix 4 (with the incorporation of the CAEP/1 proposed changes) provide a consistent and repeatable methodology for noise certification of helicopters.
- 2) The random aggregate variation, resulting from numerous independent sources of variation, leads to a standard deviation of approximately 1 dB for the EPNL metric.

Other program findings include:

- A Within a given test program and a given test series the acoustical data are quite repeatable and statistically well behaved. (See Section 8.2.1)
- B Within a given test program pilot to pilot differences are generally insignificant. (See Section 8.2.2)
- C Test day to test day differences are generally very small for the same helicopter and the same data acquisition team. (See Section 8.2.3)
- D Differences do exist between measurement programs possibly suggesting that differences may exist between one helicopter and the next of the same make and model.
- E For the test helicopter, approach operations are very repeatable and not apparently influenced by the degree of guidance provided. (See Section 8.2.5)
- F The Bell manufacturer's "Quiet Approach" procedure results in lower noise levels (approximately 2 to 4 EPNdB) than the ICAO 6 degree approach operation. (See Section 8.2.6)
- G Alternative approach operations noise levels vary from the ICAO 6 degree approach operation noise levels. (See Section 8.2.6)
- H The ICAO 6 degree approach operation for the 206L-1,3 produces distinct left-right directivity patterns. (See Section 8.2.7)
- I Though the approach operation appears repeatable in this program, one program participant observed that another helicopter type might exhibit greater variability if the certification flight test regime for that model encroached on a sensitive blade vortex interaction region.

### 8.1.2 Summary of Results

Table 8.1.A below is a summary of the overall individual operation metric multi-nation summary data comparison tables in Appendix A. In Table 8.1.A the 3-mic average multi-nation mean values are presented along with the standard deviation and 90% confidence interval (CI) values denoting the variation among the participant teams. The standard deviation and confidence interval data reveal the fundamental variability in the noise certification process as observed in the HNMMP.

TABLE 8.1.A  
PROGRAM AVERAGE 3-MIC NOISE LEVELS

|          | APPROACH | TAKEOFF | LEVEL FLYOVER |
|----------|----------|---------|---------------|
| EPNL     | 90.16    | 87.26   | 87.89         |
| STD.DEV. | .61      | .41     | .39           |
| 90% CI   | .58      | .43     | .49           |
| PNLTM    | 90.43    | 88.27   | 89.64         |
| STD.DEV. | .73      | .51     | .39           |
| 90% CI   | .72      | .54     | .50           |
| SEL      | 86.79    | 83.20   | 83.15         |
| STD.DEV. | .48      | .42     | .37           |
| 90% CI   | .45      | .56     | .48           |
| ALm      | 76.80    | 73.08   | 74.75         |
| STD.DEV. | .66      | .50     | .47           |
| 90% CI   | .56      | .54     | .46           |

## 8.2 MULTI-NATION COMPARISON ANALYSES

### 8.2.1 Statistical Stability of the Results

Within a given test program and a given test series the acoustical data are quite repeatable and statistically well behaved. The statistical repeatability of each team's 3-mic average results are shown in Tables 8.2.A through 8.2.C. These tables show the standard deviations and 90 % CI values each team arrived at in determining the averages of the 3-mic averages.

### 8.2.2 Pilot to Pilot Repeatability

It has been speculated that variation in measured helicopter noise may be associated with pilot technique. In order to examine pilot to pilot differences the HNMMP test plan called for identical flight operations to be flown by two different pilots.

Two pilots repeated operations in three of the test programs. (In the US/Canadian test each pilot flew a second time on a different day, for a total of four repeats of the core operations). Tables 8.2.D through 8.2.F present 3-mic average data for each pilot, the delta between pilots in a test and the average of the deltas. As seen in the tables (one for each operation), pilot to pilot differences are extremely small and in general not statistically significant.

#### 8.2.3 Test Day to Test Day Repeatability

Another issue related to certification testing is the day to day repeatability of operations by the same pilot. The analysis of any variance between operations conducted by the same test group, at the same location, with the same helicopter and the same pilot should point out meteorological influences on noise data (if all instrument influences remained the same).

The only program able to examine this subject was the US/Canadian test program; the entire core program was conducted by two different pilots on two different days. Tables 8.2.G through 8.2.I are summaries of the relevant data.

Statistical analyses for significance were performed on this data and in general the differences from one test day to the next are not significant. However, there is an exception in the case of the second pilot second occurrence, for takeoff and level flyover. The data associated with these series--both meteorological data, flight test and noise data--are candidates for further study.

#### 8.2.4 Program to Program Repeatability

Again, noting that there was general repeatability from program to program, the opportunity remains to investigate observed differences and explore whether or not the certification process can be further improved.

To further examine program to program repeatability one team took measurements at two test programs; the US test team participated, not only in the US/Canadian test program, but also deployed one (1.2m) measurement system at the centerline-center site during the joint French/Italian test. Unfortunately, the US data measured at the French/Italian test has not yet been fully corrected and thus cannot be compared to fully corrected US data from the US/Canadian test. This, however, would be a very interesting area for future study.

#### 8.2.5 Guided Versus Unguided Approach

The question of whether or not the degree of guidance provided during an approach operation might influence resulting sound levels was raised during the A-109A program (a predecessor to the HNMRP). It was suggested in that program that too much guidance might result in over-controlling, which in turn would result in transient loads on the rotor system and create variation in sound levels. In order to explore this concern, the HNMRP test plan requested

incorporation of guided approaches (where pilots would receive both verbal and visual flight path guidance) and unguided approaches (where pilots would be limited to an approach initiation point--altitude at a given position--, a descent rate, and an airspeed).

As shown in Table 8.2.J, guided versus unguided approach operation results show that differences in approach guidance were in general not statistically significant for the Bell 206L-1 (-3), and thus apparently not influenced by the degree of guidance provided. It should be noted, however, that the stable nature of the approach characteristics of the Bell 206L-1 (-3) may have lead to the low scatter between guidance methods and that other helicopter types, with different characteristics, may produce different results.

#### 8.2.6 Approach Angles Examined

This section contains three tables (8.2.K, 8.2.L and 8.2.M), each comparing noise levels for the six degree ICAO approach operation with an alternative approach operation (the Bell "Quiet" approach, a nine degree approach, and a six degree Vy+20 approach). The results demonstrate that for the Bell 206L-1 (-3) helicopter the six degree ICAO operation is on average 2 to 3 dB louder than the alternative operations. These results (along with other reported noise measurement flight test data) confirm that the ICAO approach operation is, generally speaking, a worst noise case flight regime which is consistent with the intent of the authors of ICAO Annex 16. The subject of alternative approach procedures for noise certification has been recommended for further consideration by Working Group II.

#### 8.2.7 Left Right Directivity

Source radiation "left-right" directivity patterns present a "fingerprint" of the acoustical radiation characteristics of the test helicopter for the ICAO certification operations. In theory these "fingerprints" should not differ significantly from one test to the next. However, the results of this analysis can be very useful in discovering whether one model of the test helicopter is intrinsically different from another model, or whether ambient wind conditions or other external forces are intervening creating divergence in relative left-right side noise levels, and possibly overall certification levels.

The data "fingerprint" plots and data tables are presented in Appendix A. The plots are presented overlaid on top of one another in groups which are generally similar. This format, while somewhat busy, is essential in providing a visual inter-program comparison. Legends accompany each plot identifying the program participant and/or series repetition. The plots provide a great deal of instant insight into which test program's data deviated "in form" as well as in level. That is to say, a data set which had a three microphone average on the low edge of the scatter band but had a directivity pattern very consistent with other test programs is in many ways less anomalous than a set with a mean value in the midst of the data scatter but with a distinctly different directivity pattern.

It is important to note that for the certification metric, EPNL, overall

repeatability was excellent. At the same time, an important opportunity exists to examine the differences which were observed. It should be possible in future analyses of the HNMRP data to probe some of the team to team differences observed within a given test program where different measurement teams were working side-by-side.

#### 8.2.8 Ground and 1.2 Meter Microphone Data Compared

The purpose of comparing ground and 1.2 m microphone data measured at the same site is to establish whether ground surface characteristics or microphone placement may be areas of concern in attempts to isolate variation in HNMRP data. The end product of such a comparison is to determine if similar or dissimilar ground impedance exists, in turn indicating a source of bias either does or does not exist.

Tables 8.2.N, 8.2.O, and 8.2.P provide summary comparisons of ground minus 1.2 meter microphone noise level differences for the three certification operations. The tables show that, in general the results are consistent.

#### 8.2.9 Static Flight Idle

The objective of the static analysis is to remove the complexity of forward flight effects and examine whether gross differences in source characteristics are apparent. The discovery of significant differences in directivity and/or sound level may indicate to investigators that environmental or source emission idiosyncrasies are present in one test program or the other. The analyses in this section focus on the static flight-idle operation. Other static operations were conducted in several of the test programs and may be the topic of future WG II (1987-1990) analyses.

Acquisition of repeatable and stable static data is at times a difficult task because of the temporal and directive fluctuations in sound levels coupled with the anomalies of sound propagation along the ground plane. In order to compensate for these instabilities the test design called for measurement of the time averaged A-weighted sound level (LEQ), over a 60-second period. Data samples were to be acquired for acoustical emission directivity angles established every 45 degrees from the nose of the helicopter (zero degrees), in a clockwise fashion. In addition, it was recommended that data be acquired for two separate propagation paths, one a nominally level "soft" path (a ground surface composed of mixed grasses), the other a hard path (a ground surface which is highly reflective and uniform in composition).

Results of static tests are summarized in Table 8.2.Q and Figure 8.2.A for the "hard" propagation path scenario and in Table 8.2.R and Figure 8.2.B for the "soft" propagation path scenario. As with the left-right directivity plots, the static plots are presented overlaid in similar groups.

During the various phases of the HNMRP there were discussions concerning the acquisition of static data, below is a summary of observations made during these discussions.

1. It is evident that an isothermal condition with no wind would be the preferred condition for assessment of static data.
2. It was observed that hover in ground effect operations are prone to wide variation in levels (15 dB for certain helicopters) over a 30-second time interval.
3. It was pointed out that positioning of the aircraft, relative to the microphones,--particularly during the tail-on conditions--will need to be carried out very carefully to avoid systematic errors in mapping the directivity curves.
4. It was noted that there are several physical phenomena that influence the diminution of sound over the ground; among which spreading loss, excess ground attenuation and refraction are considered dominant in controlling propagation.
5. It was observed that the presence of temperature inversions can result in a shadow region.
6. It was noted that micrometeorology, the rate of surface heat loss, the specific heat of the ground surface, the rate of heating for the dissimilar surfaces and test site wind conditions may play significant roles in influencing static test results.
7. It was further noted that, as suggested in a number of working papers submitted by Poland and the USSR over the past several years, the scatter in the reported data provide some indication of the difficulty one might encounter in a sound intensity static operation certification process.

#### 8.2.10 Meteorological Data

Figures 8.2.C through 8.2.E show the wide range of test conditions under which the noise measurement test results were achieved. Given the general repeatability of the HNMMP multi-nation comparison data, it would appear that the temperature and relative humidity data are not a significant factor when the data are corrected to the "standard acoustical day," 77% RH, 25 degrees Celsius.

A more thorough presentation of meteorological data is given in Appendix B where the specific meteorological conditions under which each test was conducted are identified.

## **Section 8.2**

### **Tables and Figures**

UK delta 3 calculated at 15°C

## Table 8.2.A

STATISTICAL REPEATABILITY OF S-MIC AVERAGES  
TAKE-OFF DATA EXPRESSED IN DECIBELS (dB)

| PARTICIPANT      | EPNL |      |          | PNLT <sub>a</sub> |      |          | SEL  |      |          | ALB  |      |          |
|------------------|------|------|----------|-------------------|------|----------|------|------|----------|------|------|----------|
|                  | STD  | DEV  | 90% C.I. | STD               | DEV  | 90% C.I. | STD  | DEV  | 90% C.I. | STD  | DEV  | 90% C.I. |
| AUSTRALIA        | 0.39 | 0.17 | 0.48     | 0.21              | NA   | NA       | 0.62 | 0.27 | NA       | NA   | NA   | NA       |
| JAPAN-PILOT 1    | 0.30 | 0.20 | 0.32     | 0.20              | NA   | NA       | NA   | NA   | NA       | NA   | NA   | NA       |
| JAPAN-PILOT 2    | 0.50 | 0.30 | 0.56     | 0.35              | NA   | NA       | NA   | NA   | NA       | NA   | NA   | NA       |
| FRANCE-AERO      | 0.64 | 0.53 | 0.86     | 0.71              | NA   | NA       | NA   | NA   | NA       | NA   | NA   | NA       |
| FRANCE-STNA      | 0.40 | 0.30 | 0.50     | 0.40              | 0.30 | 0.20     | 0.30 | 0.20 | 0.20     | 0.30 | 0.20 | 0.20     |
| ITALY            | NA   | NA   | NA       | NA                | NA   | NA       | NA   | NA   | NA       | NA   | NA   | NA       |
| FRG-PILOT 1      | 0.30 | 0.30 | 0.30     | 0.30              | 0.30 | 0.30     | 0.30 | 0.30 | 0.30     | 0.30 | 0.30 | 0.30     |
| FRG-PILOT 2      | 0.10 | 0.09 | 0.20     | 0.10              | 0.20 | 0.20     | 0.20 | 0.40 | 0.40     | 0.40 | 0.40 | 0.40     |
| UK-PILOT 1       | 0.40 | 0.30 | 0.30     | 0.30              | 0.30 | 0.30     | 0.30 | 0.30 | 0.30     | 0.30 | 0.30 | 0.30     |
| UK-PILOT 2       | 0.20 | 0.20 | 0.30     | 0.30              | 0.30 | 0.20     | 0.30 | 0.60 | 0.50     | 0.50 | 0.50 | 0.50     |
| CANADA-PILOT 1-1 | 0.17 | 0.29 | 0.55     | 0.93              | 0.32 | 0.54     | 0.68 | 0.14 | NA       | NA   | NA   | NA       |
| CANADA-PILOT 1-2 | 0.08 | 0.35 | 0.02     | 0.07              | 0.26 | 1.16     | 0.03 | 0.14 | NA       | NA   | NA   | NA       |
| CANADA-PILOT 2-1 | 0.86 | 1.45 | 0.79     | 1.34              | 0.91 | 1.53     | 0.82 | 1.38 | NA       | NA   | NA   | NA       |
| CANADA-PILOT 2-2 | 0.92 | 1.56 | 1.37     | 2.31              | 0.87 | 1.47     | 1.29 | 2.17 | NA       | NA   | NA   | NA       |
| US-PILOT 1-1     | 0.31 | 0.21 | 0.55     | 0.37              | 0.25 | 0.17     | 0.45 | 0.30 | NA       | NA   | NA   | NA       |
| US-PILOT 1-2     | 0.25 | 0.23 | 0.18     | 0.17              | 0.24 | 0.23     | 0.43 | 0.41 | NA       | NA   | NA   | NA       |
| US-PILOT 2-1     | 0.59 | 0.44 | 0.49     | 0.36              | 0.65 | 0.48     | 0.62 | 0.45 | NA       | NA   | NA   | NA       |
| US-PILOT 2-2     | 0.63 | 0.52 | 0.86     | 0.71              | 0.58 | 0.48     | 0.73 | 0.60 | NA       | NA   | NA   | NA       |
| AVERAGE          | 0.41 | 0.43 | 0.51     | 0.54              | 0.42 | 0.56     | 0.50 | 0.54 | NA       | NA   | NA   | NA       |
| STD DEV          | 0.25 | 0.42 | 0.32     | 0.56              | 0.25 | 0.49     | 0.32 | 0.56 | NA       | NA   | NA   | NA       |
| 90% C.I.         | 0.15 | 0.27 | 0.20     | 0.35              | 0.18 | 0.37     | 0.23 | 0.40 | NA       | NA   | NA   | NA       |

## Table 8.2.B

STATISTICAL REPEATABILITY OF T-MIC AVERAGE  
APPROACH DATA EXPRESSED IN DEGREES (dE)

| PARTICIPANT      | EFNL |      |          | FNLTA |      |          | SEL  |      |          | T-MIC |      |          |
|------------------|------|------|----------|-------|------|----------|------|------|----------|-------|------|----------|
|                  | STD  | DEV  | 90% C.I. | STD   | DEV  | 90% C.I. | STD  | DEV  | 90% C.I. | STD   | DEV  | 90% C.I. |
| AUSTRALIA        | 0.98 | 0.66 | 1.11     | 0.74  | NA   | NA       | NA   | NA   | NA       | 0.74  | 0.74 | 0.74     |
| JAPAN-PILOT 1    | 0.80 | 0.69 | 0.38     | 0.76  | NA   | NA       | NA   | NA   | NA       | NA    | NA   | NA       |
| JAPAN-PILOT 2    | 0.80 | 0.50 | 0.64     | 0.79  | NA   | NA       | NA   | NA   | NA       | NA    | NA   | NA       |
| FRANCE-AERO      | 0.84 | 1.42 | 1.22     | 2.96  | NA   | NA       | NA   | NA   | NA       | NA    | NA   | NA       |
| FRANCE-STNA      | 0.60 | 0.40 | 1.80     | 1.30  | 0.60 | 0.50     | 1.20 | 0.50 | 1.20     | 0.70  | 0.70 | 0.70     |
| ITALY            | NA   | NA   | NA       | NA    | NA   | NA       | NA   | NA   | NA       | NA    | NA   | NA       |
| FRG-PILOT 1      | 0.60 | 0.40 | 0.60     | 0.40  | 0.80 | 0.50     | 0.50 | 0.50 | 0.50     | 0.70  | 0.70 | 0.70     |
| FRG-PILOT 2      | 0.50 | 0.40 | 0.80     | 0.70  | 0.30 | 0.30     | 0.50 | 0.30 | 0.50     | 0.40  | 0.40 | 0.40     |
| UK-PILOT 1       | 0.50 | 0.40 | 0.80     | 0.70  | 0.50 | 0.40     | 0.90 | 0.40 | 0.90     | 0.70  | 0.70 | 0.70     |
| CANADA-PILOT 1-2 | 0.13 | 0.58 | 0.32     | 1.44  | 0.13 | 0.58     | 0.12 | 0.58 | 0.12     | 0.53  | 0.53 | 0.53     |
| CANADA-PILOT 2-1 | 0.61 | 1.03 | 0.26     | 0.43  | 0.50 | 0.84     | 0.47 | 0.84 | 0.47     | 0.79  | 0.79 | 0.79     |
| US-PILOT 1-1     | 0.55 | 0.40 | 0.87     | 0.58  | 0.53 | 0.35     | 0.82 | 0.53 | 0.82     | 0.55  | 0.55 | 0.55     |
| US-PILOT 1-2     | 0.41 | 0.39 | 0.38     | 0.36  | 0.36 | 0.34     | 0.49 | 0.36 | 0.49     | 0.46  | 0.46 | 0.46     |
| US-PILOT 2-1     | 0.71 | 0.52 | 0.58     | 0.42  | 0.63 | 0.46     | 0.54 | 0.63 | 0.54     | 0.40  | 0.40 | 0.40     |
| US-PILOT 2-2     | 0.52 | 0.35 | 0.43     | 0.26  | 0.44 | 0.27     | 0.58 | 0.44 | 0.58     | 0.36  | 0.36 | 0.36     |
| AVERAGE          | 0.61 | 0.58 | 0.73     | 0.78  | 0.48 | 0.45     | 0.66 | 0.58 | 0.66     | 0.56  | 0.56 | 0.56     |
| STD DEV          | 0.21 | 0.30 | 0.42     | 0.72  | 0.19 | 0.17     | 0.32 | 0.19 | 0.32     | 0.20  | 0.20 | 0.20     |
| 90% C.I.         | 0.15 | 0.21 | 0.30     | 0.51  | 0.17 | 0.15     | 0.28 | 0.17 | 0.28     | 0.16  | 0.16 | 0.16     |

## Table 8.2.C

PARTICIPANT PERIODICITY OF 0-MIC AVERAGES  
LEVEL FOR OVER 100% EXPRESSED IN DECIBELS (dB)

| PARTICIPANT      | PERIODICITY |      | PERIODICITY |      | PERIODICITY |      | PERIODICITY |      |
|------------------|-------------|------|-------------|------|-------------|------|-------------|------|
|                  | STD         | DEV  | STD         | DEV  | STD         | DEV  | STD         | DEV  |
| AUSTRALIA        | 0.32        | 0.25 | 0.51        | 0.33 | NA          | NA   | 0.56        | 0.31 |
| JAPAN-PILOT 1-1  | 0.4         | 0.59 | 0.74        | 0.16 | NA          | NA   | NA          | NA   |
| JAPAN-PILOT 1-2  | 0.40        | 0.77 | 0.71        | 0.52 | NA          | NA   | NA          | NA   |
| JAPAN-PILOT 2-1  | 0.50        | 0.79 | 0.78        | 0.44 | NA          | NA   | NA          | NA   |
| JAPAN-PILOT 2-2  | 0.46        | 0.56 | 0.16        | 0.19 | NA          | NA   | NA          | NA   |
| FRANCE-AERG      | 0.36        | 0.43 | 0.64        | 0.75 | NA          | NA   | NA          | NA   |
| FRANCE-STNA      | 0.46        | 0.56 | 0.66        | 0.80 | 0.36        | 0.30 | 0.50        | 0.50 |
| ITALY            | NA          | NA   | NA          | NA   | NA          | NA   | NA          | NA   |
| FRG-PILOT 1      | 0.30        | 0.29 | 0.20        | 0.20 | 0.26        | 0.20 | 0.30        | 0.30 |
| FRG-PILOT 2      | 0.30        | 0.30 | 0.30        | 0.36 | 0.60        | 0.50 | 0.80        | 0.70 |
| UK-PILOT 1       | NA          | NA   | NA          | NA   | 0.20        | 0.20 | 0.30        | 0.20 |
| CANADA-PILOT 1-1 | 0.22        | 0.21 | 0.27        | 0.26 | 0.32        | 0.31 | 0.48        | 0.46 |
| CANADA-PILOT 1-2 | 0.58        | 0.68 | 0.60        | 0.71 | 0.60        | 0.71 | 0.69        | 0.81 |
| CANADA-PILOT 2-1 | 0.46        | 0.66 | 0.47        | 2.09 | 0.44        | 1.95 | 0.14        | 0.61 |
| CANADA-PILOT 2-2 | 0.43        | 0.51 | 0.80        | 0.94 | 0.57        | 0.67 | 0.93        | 1.10 |
| US-PILOT 1-1     | 0.29        | 0.21 | 0.27        | 0.20 | 0.23        | 0.17 | 0.26        | 0.19 |
| US-PILOT 1-2     | 0.16        | 0.19 | 0.14        | 0.16 | 0.23        | 0.27 | 0.17        | 0.20 |
| US-PILOT 2-1     | 0.30        | 0.25 | 0.22        | 0.19 | 0.27        | 0.22 | 0.36        | 0.30 |
| US-PILOT 2-2     | 0.45        | 0.30 | 0.46        | 0.28 | 0.43        | 0.27 | 0.59        | 0.36 |
| AVERAGE          | 0.40        | 0.51 | 0.39        | 0.50 | 0.37        | 0.48 | 0.47        | 0.46 |
| STD DEV          | 0.14        | 0.44 | 0.20        | 0.48 | 0.16        | 0.50 | 0.24        | 0.27 |
| % C. I.          | 0.09        | 0.27 | 0.13        | 0.10 | 0.12        | 0.39 | 0.18        | 0.20 |

UK delta 3 calculated at 15° C

Table 8.2.D

PILOT TO FLIGHT RECEIVERSHIP,  
TAKE-OFF WITH EXPRESS IN DECIBELS - 100.

Table 8.2.E

|            | EFNL    | FALIN   | SEL     | Avg     |
|------------|---------|---------|---------|---------|
|            | 3 MIC   | 3 MIC   | 3 MIC   | 3 MIC   |
|            | AVERAGE | AVERAGE | AVERAGE | AVERAGE |
| FRONT SPOT | 1.17    | 1.17    | 1.17    | 1.17    |
| FRONT SPOT | 1.17    | 1.17    | 1.17    | 1.17    |

PILOT TO FLOOR! REPEATABILITY  
LEVEL FLOWOVER DATA EXPRESSED

| PARTICIPANT | EFNL    | FNLTA   | SEL     | ALB     |
|-------------|---------|---------|---------|---------|
|             | 3 MIC   | 3 MIC   | 3 MIC   | 3 MIC   |
|             | AVERAGE | AVERAGE | AVERAGE | AVERAGE |
|             |         |         |         |         |

|                 |       |       |    |
|-----------------|-------|-------|----|
| JAFAN-PILOT 1-1 | 89.20 | 90.42 | NA |
| JAFAN-PILOT 2-1 | 88.99 | 90.53 | NA |
| DELTA           | 0.39  | 0.51  | NA |

|                 |       |       |    |    |
|-----------------|-------|-------|----|----|
| JAPAN-PILOT 1-2 | 86.69 | 89.98 | NA | NA |
| JAPAN-PILOT 2-2 | 85.49 | 90.57 | NA | NA |
| DELTA           | 9.99  | 0.59  | NA | NA |

|       | FRG-PILOT 1 | FRG-PILOT 2 | DELTIA | FRG-PILOT 1 | FRG-PILOT 2 | DELTIA |
|-------|-------------|-------------|--------|-------------|-------------|--------|
| 86.50 | 86.24       | 0.50        | 80.70  | 81.50       | 0.80        | 72.24  |
| 87.20 | 86.70       | 0.50        | 81.50  | 81.90       | 0.40        | 75.00  |
| 0.50  | 0.50        | 0.00        | 0.90   | 0.90        | 0.00        | 0.80   |

|         | CANADA-PILOT 1 | CANADA-PILOT 2 | CANADA-PILOT 3 | CANADA-PILOT 4 | CANADA-PILOT 5 |
|---------|----------------|----------------|----------------|----------------|----------------|
| ALPHA   | 88.53          | 88.53          | 88.53          | 88.53          | 88.53          |
| BRAVO   | 88.16          | 88.16          | 88.16          | 88.16          | 88.16          |
| CHARLIE | 0.38           | 0.38           | 0.38           | 0.38           | 0.38           |
| DELTA   |                |                |                |                |                |
| EPSILON |                |                |                |                |                |
| FOXTROT |                |                |                |                |                |
| GOLF    |                |                |                |                |                |
| PIPER   |                |                |                |                |                |
| RIO     |                |                |                |                |                |
| SIGMA   |                |                |                |                |                |
| TANGO   |                |                |                |                |                |
| UNIFORM |                |                |                |                |                |
| VIKI    |                |                |                |                |                |
| ZULU    |                |                |                |                |                |

|       | CANADA-PILOT | US-PILOT | US-PILOT 1-1 |
|-------|--------------|----------|--------------|
| DEC14 | 88.98        | 86.89    | 86.49        |
| DEC14 | 9.41         | 1.34     | 1.10         |
| DEC14 | 90.87        | 84.98    | 82.11        |
| DEC14 | 1.34         | 1.10     | 1.50         |

|              | 0.25  | 0.50  | 0.75  | 0.90  |
|--------------|-------|-------|-------|-------|
| US-FLU01 1/2 | 87.70 | 86.70 | 87.70 | 86.70 |
| US-FLU01 2/2 | 87.00 | 88.70 | 84.70 | 86.70 |

| DELTA         | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 |
|---------------|------|------|------|------|------|
| AVG. OF DELTA | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 |
| STD. DE.      | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 |
| S.E.          | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |

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## Table 8.2.G

TEST DAY TO TEST DAY REPEATABILITY  
TAKE-OFF EPNL DATA EXPRESSED IN DECIBELS -dB

| PARTICIPANT      | LEFT     | CENTER LINE | RIGHT    |         |
|------------------|----------|-------------|----------|---------|
|                  | SIDELINE | CENTER      | SIDELINE | 1 MIC   |
|                  | AVERAGE  | AVERAGE     | AVERAGE  | AVERAGE |
| CANADA-PILOT 1-1 | 87.16    | 87.05       | 87.75    | 87.61   |
| CANADA-PILOT 1-2 | 88.54    | 87.11       | 85.97    | 87.19   |
| DELTA            | 1.78     | 1.25        | 1.82     | 1.43    |
| CANADA-PILOT 2-1 | 87.74    | 88.16       | 85.7     | 87.31   |
| CANADA-PILOT 2-2 | 88.46    | 87.25       | 87.65    | 87.99   |
| DELTA            | 1.87     | 1.19        | 1.82     | 1.68    |
| US-PILOT 1-1     | 86.91    | 86.17       | 86.17    | 86.69   |
| US-PILOT 1-2     | 87.41    | 86.49       | 86.99    | 86.61   |
| DELTA            | 1.51     | 1.17        | 1.31     | 1.23    |
| US-PILOT 2-1     | 87.04    | 87.71       | 86.51    | 87.11   |
| US-PILOT 2-2     | 89.17    | 89.49       | 87.7     | 88.6    |
| DELTA            | 1.79     | 1.71        | 1.83     | 1.46    |
| AVG. OF DELTA    | 1.95     | 1.80        | 1.77     | 1.81    |
| STD. DEV.        | 1.51     | 1.71        | 1.71     | 1.59    |
| PER CENT         | 1.08     | 1.61        | 1.61     | 1.33    |

## Table 8.2.H

TEST DAY TO TEST DAY REPEATABILITY  
ARRIVAL EPNL DATA EXPRESSED IN DECIBELS -dB

| PARTICIPANT   | LEFT     | CENTER LINE | RIGHT    |         |
|---------------|----------|-------------|----------|---------|
|               | SIDELINE | CENTER      | SIDELINE | 1 MIC   |
|               | AVERAGE  | AVERAGE     | AVERAGE  | AVERAGE |
| US PILOT 1-1  | 87.11    | 87.5        | 87.1     | 87.11   |
| US PILOT 1-2  | 87.01    | 87.1        | 87.4     | 87.11   |
| DELTA         | 1.7      | 1.27        | 1.6      | 1.22    |
| US PILOT 2-1  | 86.4     | 87.4        | 87.3     | 87.1    |
| US PILOT 2-2  | 87.1     | 87.8        | 87.4     | 87.1    |
| DELTA         | 1.7      | 1.4         | 1.6      | 1.4     |
| AVG. OF DELTA | 1.6      | 1.3         | 1.5      | 1.3     |
| STD. DEV.     | 1.28     | 1.4         | 1.4      | 1.28    |
| PER CENT      | 0.95     | 1.04        | 1.04     | 1.05    |

## Table 8.2.I

TEST DAY TO TEST DAY REPEATABILITY  
LEVEL FLYOVER EPNL DATA EXPRESSED IN DECIBELS (dB)

| PARTICIPANT      | LEFT     | CENTER LINE | RIGHT    | ± MIC |       |
|------------------|----------|-------------|----------|-------|-------|
|                  | SIDELINE | CENTER      | SIDELINE |       |       |
| <hr/>            |          |             |          |       |       |
| CANADA-PILOT 1-1 | 88.53    | 88.87       | 88.74    | 1     | 88.54 |
| CANADA-PILOT 1-1 | 88.55    | 88.38       | 87.29    | 1     | 88.07 |
| DELTA            | 0.04     | 0.29        | 1.05     |       | 0.47  |
| CANADA-PILOT 2-1 | 87.61    | 88.77       | 88.12    | 1     | 88.16 |
| CANADA-PILOT 2-2 | 89.42    | 88.58       | 88.94    | 1     | 88.98 |
| DELTA            | 1.81     | 0.19        | 0.82     |       | 0.82  |
| US-PILOT 1-1     | 87.39    | 88.80       | 88.39    | 1     | 88.80 |
| US-PILOT 1-2     | 87.70    | 87.70       | 86.30    | 1     | 87.20 |
| DELTA            | 0.40     | 0.90        | 0.90     |       | 0.40  |
| US-PILOT 2-1     | 87.39    | 87.50       | 86.20    | 1     | 87.00 |
| US-PILOT 2-2     | 88.50    | 87.00       | 87.30    | 1     | 87.60 |
| DELTA            | 1.30     | 0.50        | 1.10     |       | 0.60  |
| <hr/>            |          |             |          |       |       |
| Avg. OF DELTA    | 0.89     | 0.47        | 0.74     | 1     | 0.57  |
| STD. DEV.        | 0.81     | 0.31        | 0.51     | 1     | 0.19  |
| %C.C.I.          | 1.84     | 0.71        | 1.16     | 1     | 0.42  |
| <hr/>            |          |             |          |       |       |

**Table 8.2.J**

| EPNL 3 MICROPHONE AVERAGE |                 |                   |       |
|---------------------------|-----------------|-------------------|-------|
| PARTICIPANT               | GUIDED APPROACH | UNGUIDED APPROACH | DELTA |
| JAPAN P-1                 | 91.20           | 90.60             | 0.60  |
| JAPAN P-2                 | 91.60           | 91.20             | 0.40  |
| FRG P-1                   | 89.50           | 89.20             | 0.30  |
| FRG P-2                   | 89.60           | NA                | NA    |
| UK P-1                    | 89.47           | 90.20             | 0.73  |
| UK P-2                    | NA              | 90.00             | NA    |
| US P1-1                   | 90.20           | 90.40             | 0.20  |
| US P2-1                   | 90.10           | 89.40             | 0.70  |
| AVERAGE                   | 90.24           | 90.14             | 90.24 |
| STD. DEV.                 | 0.85            | 0.69              | 0.22  |
| 90% CI                    | 0.62            | 0.51              | 0.18  |

**Table 8.2.K**

| EPNL 3 MICROPHONE AVERAGE |               |                     |       |
|---------------------------|---------------|---------------------|-------|
| PARTICIPANT               | ICAO 6 DEGREE | BELL QUIET APPROACH | DELTA |
| FRG P-1                   | 89.50         | 86.23               | 3.27  |
| FRG P-2                   | 89.60         | NA                  | NA    |
| UK P-1                    | 89.47         | 86.40               | 3.07  |
| UK P-2                    | NA            | 86.00               | NA    |
| US P1-1                   | 90.20         | 87.53               | 2.67  |
| US P2-1                   | 90.10         | 87.60               | 2.50  |
| AVERAGE                   | 89.77         | 86.75               | 2.88  |
| STD. DEV.                 | 0.35          | 0.76                | 0.35  |
| 90% CI                    | 0.33          | 0.72                | 0.42  |

**Table 8.2.L**

| EPNL 3 MICROPHONE AVERAGE |               |                   |       |
|---------------------------|---------------|-------------------|-------|
| PARTICIPANT               | ICAO 6 DEGREE | 9 DEGREE APPROACH | DELTA |
| FRANCE-AERO 1             | 89.30         | 88.37             | 0.93  |
| FRANCE-STNA 1             | 88.37         | 86.60             | 1.77  |
| FRG P-1                   | 89.50         | 87.27             | 2.23  |
| FRG P-2                   | 89.60         | 87.73             | 1.87  |
| UK P-1                    | 89.47         | 87.60             | 1.87  |
| UK P-2                    | NA            | 88.10             | NA    |
| AVERAGE                   | 89.25         | 87.61             | 1.73  |
| STD. DEV.                 | 0.50          | 0.63              | 0.48  |
| 90% CI                    | 0.48          | 0.52              | 0.46  |

**Table 8.2.M**

| EPNL 3 MICROPHONE AVERAGE |               |                  |       |
|---------------------------|---------------|------------------|-------|
| PARTICIPANT               | ICAO 6 DEGREE | 6 DEGREE VY + 20 | DELTA |
| FRANCE-AERO 1             | 89.30         | 88.57            | 0.73  |
| FRANCE-STNA 1             | 88.37         | 87.80            | 0.57  |
| FRG P-1                   | 89.50         | 86.10            | 3.40  |
| FRG P-2                   | 89.60         | 86.10            | 3.50  |
| UK P-1                    | 89.47         | 89.50            | 0.03  |
| UK P-2                    | NA            | 89.20            | NA    |
| AVERAGE                   | 89.25         | 87.88            | 1.65  |
| STD. DEV.                 | 0.50          | 1.50             | 1.67  |
| 90% CI                    | 0.48          | 1.23             | 1.59  |

**Table 8.2.N**

GROUND MINUS 1.2 METER MICROPHONE  
TAKEOFF

| COUNTRY       | SAMPLE SIZE |          |      | DELTA dB |      |     | COUNTRY       | SAMPLE SIZE |          |      | DELTA dB |      |     |
|---------------|-------------|----------|------|----------|------|-----|---------------|-------------|----------|------|----------|------|-----|
|               | 1.2 MIC     | GRD. MIC | EPNL | SEL      | PNL1 | ALM |               | 1.2 MIC     | GRD. MIC | EPNL | SEL      | PNL1 | ALM |
| AUSTRALIA     | NA          | NA       | NA   | NA       | NA   | NA  | AUSTRALIA     | NA          | NA       | NA   | NA       | NA   | NA  |
| JAPAN PILOT 1 | 8           | 8        | 2    | 2        | NA   | NA  | JAPAN PILOT 1 | 7           | 7        | 2.4  | NA       | NA   | NA  |
| JAPAN PILOT 2 | 9           | 9        | 1.7  | NA       | NA   | NA  | JAPAN PILOT 2 | 9           | 9        | 1.8  | NA       | NA   | NA  |
| FRANCE AERO   | NA          | NA       | NA   | NA       | NA   | NA  | FRANCE AERO   | NA          | NA       | NA   | NA       | NA   | NA  |
| FRANCE STNA   | NA          | NA       | NA   | NA       | NA   | NA  | FRANCE STNA   | NA          | NA       | NA   | NA       | NA   | NA  |
| ITALY         | NA          | NA       | NA   | NA       | NA   | NA  | ITALY         | NA          | NA       | NA   | NA       | NA   | NA  |
| FRG PILOT 1   | 5           | 5        | 2.4  | 2.7      | 2.6  | 3.3 | FRG PILOT 1   | 8           | 8        | 1.9  | 3        | 1.7  | 2.2 |
| FRG PILOT 2   | 6           | 6        | 3    | 2.7      | 2.7  | 3.2 | FRG PILOT 2   | 2           | 6        | 1.8  | 1.9      | 1.7  | 2.1 |
| UK PILOT 1    | 6           | 6        | 2.5  | 1.7      | 3.1  | 2.5 | UK PILOT 1    | 6           | 6        | 2.6  | 2.5      | 2    | 2.4 |
| UK PILOT 2    | 6           | 6        | 2.8  | 1.8      | 3.3  | 2.6 | UK PILOT 2    | NA          | NA       | NA   | NA       | NA   | NA  |
| CANADA P1-1   | NA          | NA       | NA   | NA       | NA   | NA  | CANADA P1-1   | NA          | NA       | NA   | NA       | NA   | NA  |
| CANADA P1-2   | 4           | 5        | 3.7  | 3.2      | 2.7  | 2.6 | CANADA P1-2   | 5           | 5        | 2.9  | 2.8      | 1.8  | 1.7 |
| CANADA P2-1   | 7           | 7        | 3.5  | 2.8      | 3.1  | 2.6 | CANADA P2-1   | 7           | 8        | 2.7  | 2.8      | 1.7  | 1.6 |
| CANADA P2-2   | 9           | 9        | 3.6  | 2.9      | 4    | 3   | CANADA P2-2   | 9           | 9        | 2.9  | 2.7      | 2.1  | 2   |
| US P1-1       | 9           | 9        | 2.9  | 2.5      | 2.7  | 2.2 | US P1-1       | 10          | 10       | 2.6  | 2.7      | 2.4  | 2.8 |
| US P1-2       | 5           | 5        | 3    | 2.5      | 3    | 2.5 | US P1-2       | 5           | 5        | 2.5  | 2.7      | 2.5  | 2.7 |
| US P2-1       | 7           | 6        | 3.9  | 3.2      | 3.9  | 3.4 | US P2-1       | 8           | 7        | 2.4  | 2.5      | 2.3  | 2.3 |
| US P2-2       | 7           | 7        | 3.6  | 2.9      | 3.8  | 3.1 | US P2-2       | 9           | 9        | 2.7  | 2.5      | 2.5  | 2.8 |

GROUND MINUS 1.2 METER MICROPHONE  
APPROACH

**Table 8.2.O**

## Table 8.2.P

GROUND MINUS 1.2 METER MICROPHONE  
LEVEL FLYOVER

| COUNTRY         | SAMPLE SIZE |          | DELTA dB |     |       |     |
|-----------------|-------------|----------|----------|-----|-------|-----|
|                 | 1.2 MIC     | GRD. MIC | EPNL     | SEL | FNLTE | ALM |
| AUSTRALIA       | NA          | NA       | NA       | NA  | NA    | NA  |
| JAPAN PILOT 1-1 | 4           | 4        | 2.5      | NA  | NA    | NA  |
| JAPAN PILOT 1-2 | 4           | 4        | 2.1      | NA  | NA    | NA  |
| JAPAN PILOT 2-1 | 3           | 3        | 1.7      | NA  | NA    | NA  |
| JAPAN PILOT 2-2 | 4           | 4        | 1.8      | NA  | NA    | NA  |
| FRANCE AERO     | NA          | NA       | NA       | NA  | NA    | NA  |
| FRANCE STNA     | NA          | NA       | NA       | NA  | NA    | NA  |
| ITALY           | NA          | NA       | NA       | NA  | NA    | NA  |
| FRG PILOT 1     | 6           | 6        | 3.6      | 3.1 | 3.8   | 3.6 |
| FRG PILOT 2     | 5           | 5        | 1.6      | 1.3 | 1.6   | 1.7 |
| UK PILOT 1      | 6           | 6        | 2.5      | 1.8 | 3     | 2.2 |
| UK PILOT 2      | NA          | NA       | NA       | NA  | NA    | NA  |
| CANADA P1-1     | NA          | NA       | NA       | NA  | NA    | NA  |
| CANADA P1-2     | 5           | 5        | 3.4      | 3.2 | 3.1   | 2.9 |
| CANADA P2-1     | 7           | 6        | 3.1      | 3   | 2.8   | 2.9 |
| CANADA P2-2     | 12          | 11       | 3.6      | 3.4 | 3.2   | 2.9 |
| US P1-1         | 7           | 6        | 3.7      | 3.5 | 4.2   | 4   |
| US P1-2         | 4           | 4        | 2.9      | 2.8 | 3     | 2.9 |
| US P2-1         | 6           | 6        | 3.8      | 3.3 | 3.9   | 3.6 |
| US P2-2         | 11          | 11       | 3.6      | 3.2 | 3.9   | 3.5 |

UK delta 3 calculated at 15°C

**Table 8.2.Q**

FLIGHT IDLE - HARD PATH

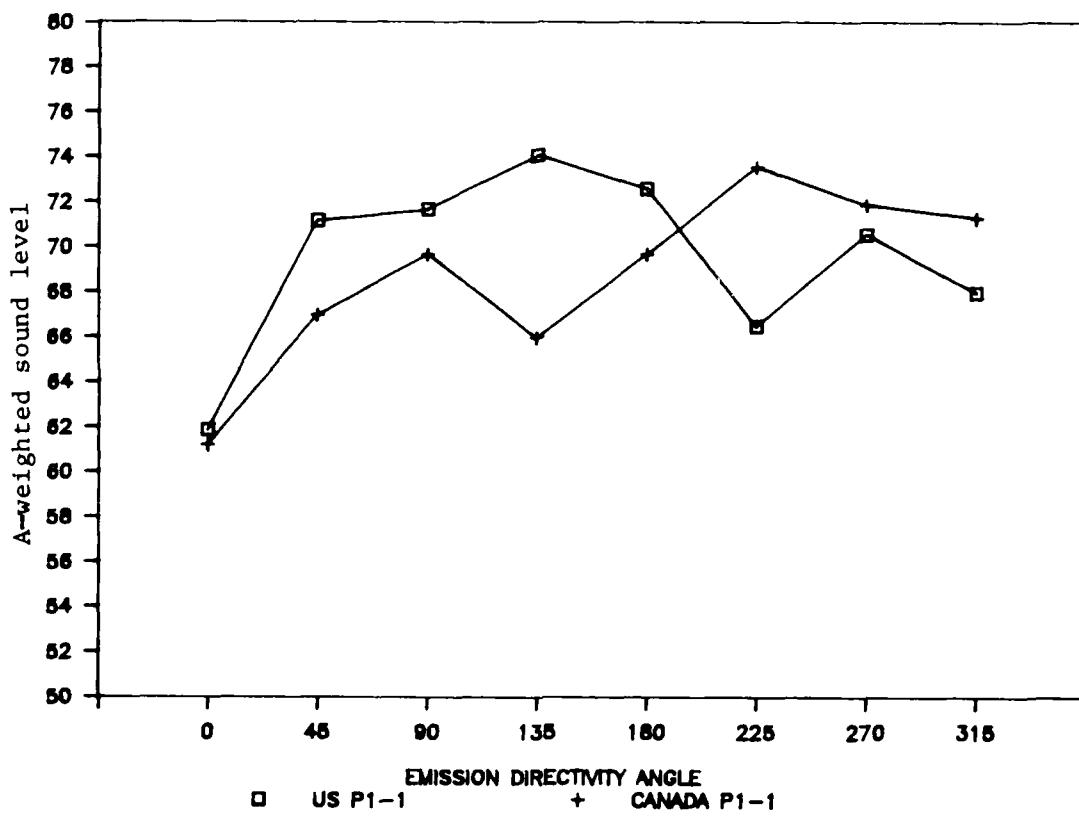
| PARTICIPANT | EMISSION ANGLE IN DEGREES |       |       |       |       |       | 315   |
|-------------|---------------------------|-------|-------|-------|-------|-------|-------|
|             | 0                         | 45    | 90    | 135   | 180   | 225   |       |
| AUSTRALIA   | 72.20                     | 72.00 | 74.50 | 72.20 | NB    | NB    | NB    |
| JAPAN       | 71.70                     | 73.80 | 77.90 | 73.90 | 75.20 | 75.00 | 75.50 |
| FRG         | 64.80                     | 65.80 | 65.60 | 65.30 | 66.30 | 67.50 | 66.10 |
| UK          | 63.00                     | 62.20 | 65.00 | 68.60 | 63.90 | 64.20 | 67.10 |
| CAN P1-1    | 61.20                     | 67.00 | 69.70 | 66.00 | 69.70 | 73.60 | 71.30 |
| US P1-1     | 61.90                     | 71.20 | 71.70 | 74.10 | 72.60 | 66.50 | 70.50 |
| CAN P1-2    | 68.30                     | 68.50 | 72.00 | 72.20 | 72.10 | 73.40 | 72.80 |
| US P1-2     | 68.80                     | 69.40 | 72.50 | 74.70 | 72.80 | 71.30 | 73.10 |
| Avg         | 66.49                     | 69.36 | 71.11 | 71.75 | 70.04 | 70.07 | 70.86 |
| STD DEV     | 1.64                      | 1.05  | 1.63  | 1.40  | 1.61  | 1.77  | 1.41  |
| 90% CI      | 1.74                      | 1.11  | 1.73  | 1.49  | 1.92  | 2.10  | 1.68  |

**Table 8.2.R**

FLIGHT IDLE - SOFT PATH

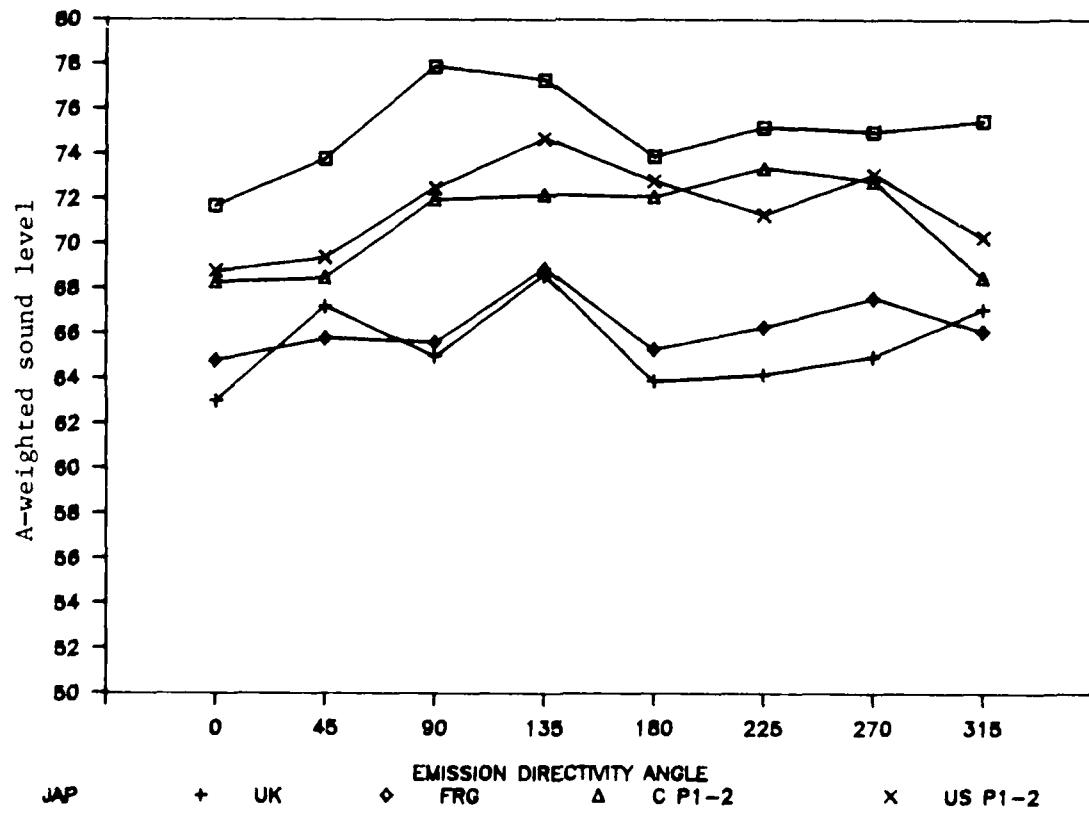
| PARTICIPANT  | EMISSION ANGLE IN DEGREES |       |       |       |       |       | 315   |
|--------------|---------------------------|-------|-------|-------|-------|-------|-------|
|              | 0                         | 45    | 90    | 135   | 180   | 225   |       |
| AUSTRALIA    | 66.80                     | 70.80 | 67.00 | 63.80 | 64.80 | 64.20 | 70.20 |
| JAPAN        | 65.10                     | 65.60 | 66.80 | 70.20 | 69.70 | 77.50 | 70.70 |
| FRG          | 54.00                     | 59.20 | 59.40 | 63.70 | 57.50 | 59.80 | 59.50 |
| UK           | 54.90                     | 58.00 | 59.10 | 63.10 | 58.20 | 61.70 | 59.30 |
| US-PILOT 1-1 | 62.90                     | 62.50 | 63.60 | 60.90 | 62.00 | 63.00 | 61.50 |
| US-PILOT 1-2 | 65.50                     | 64.50 | 65.60 | 62.90 | 62.50 | 61.50 | 58.80 |
| Avg          | 61.53                     | 63.43 | 63.58 | 64.10 | 62.45 | 64.62 | 63.93 |
| STD DEV      | 2.52                      | 2.08  | 1.60  | 1.42  | 2.01  | 2.90  | 2.43  |
| 90% CI       | 3.46                      | 2.86  | 2.19  | 1.95  | 2.76  | 3.98  | 3.34  |

### FLIGHT IDLE – HARD PATH

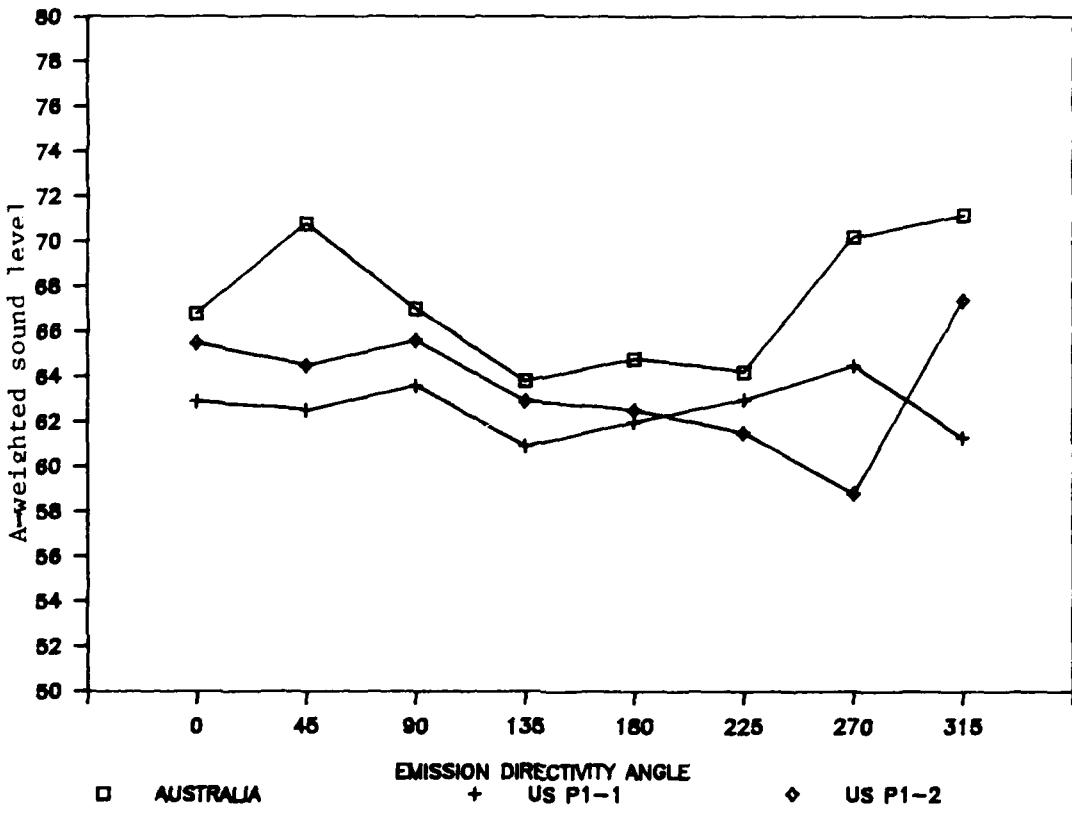


**Figure 8.2.A**

### FLIGHT IDLE – HARD PATH

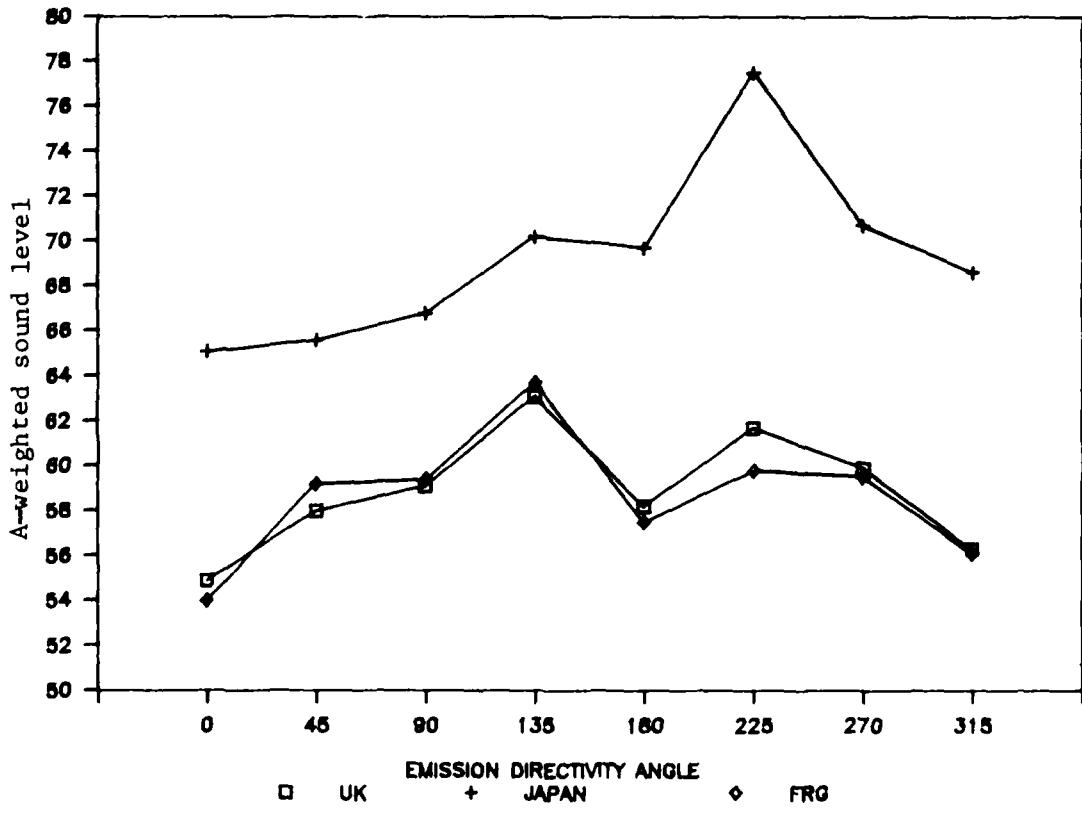


### FLIGHT IDLE - SOFT PATH



**Figure 8.2.B**

### FLIGHT IDLE - SOFT PATH



**Figure 8.2.C**

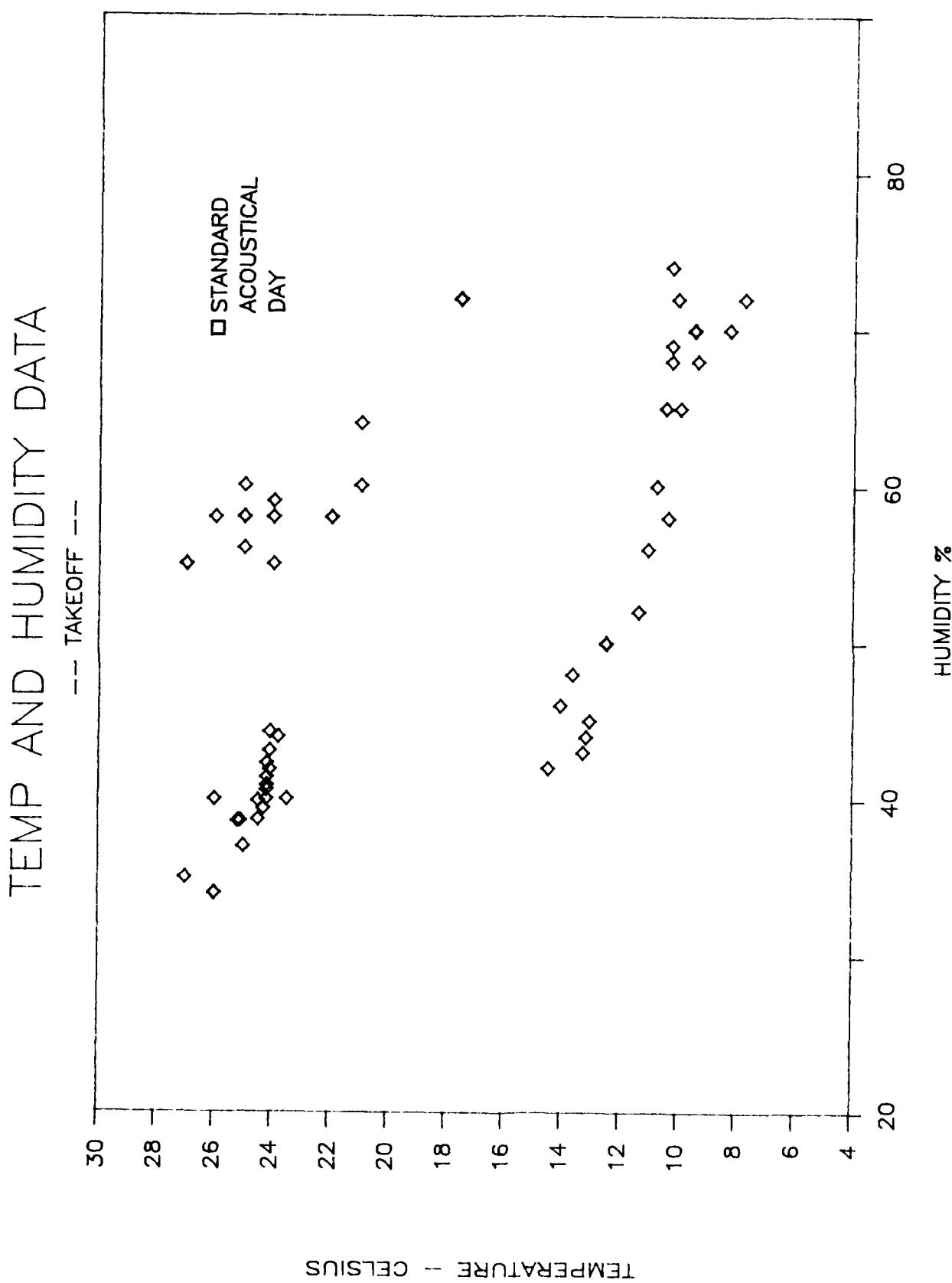


Figure 8.2.D

TEMP AND HUMIDITY DATA  
-- APPROACH --

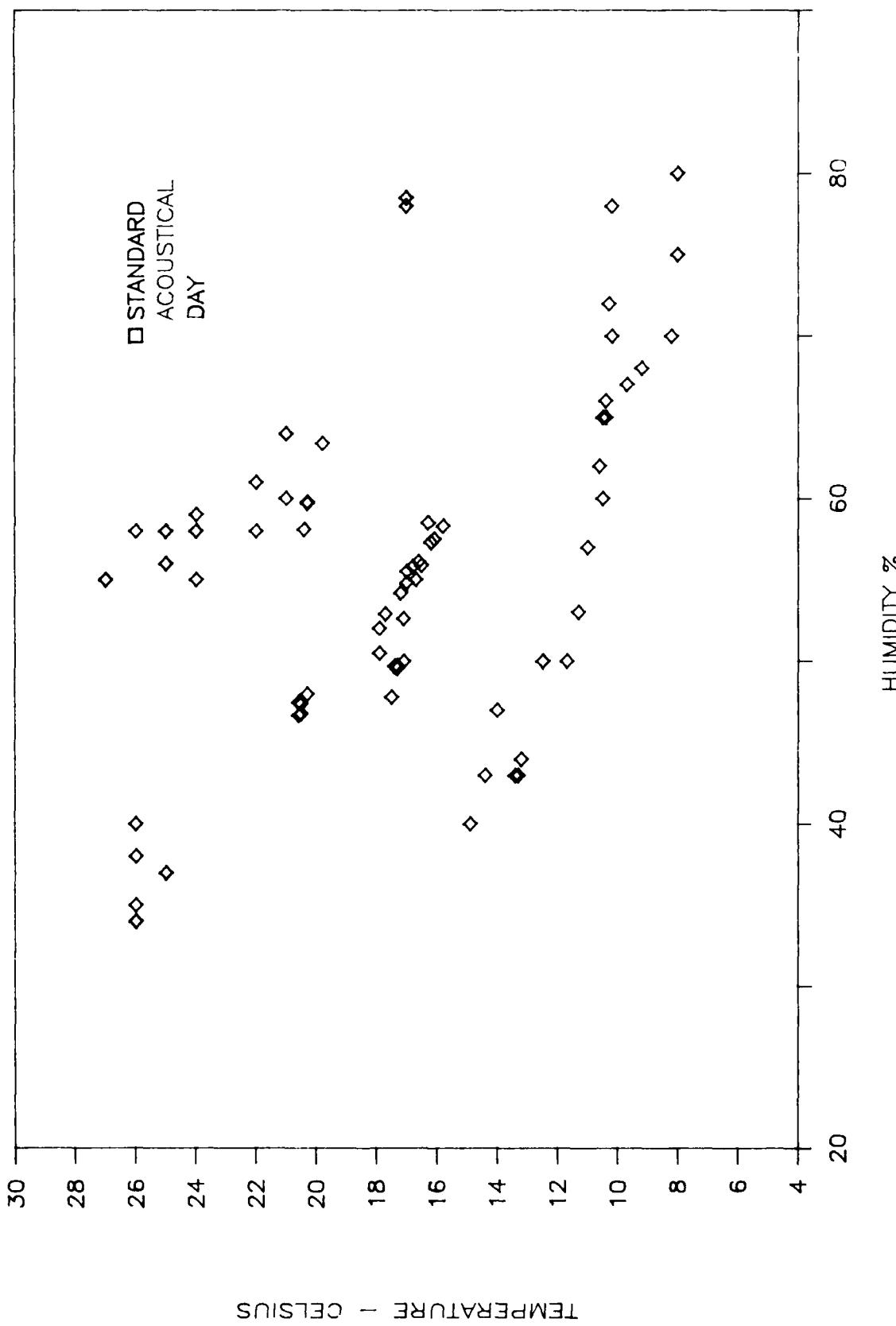
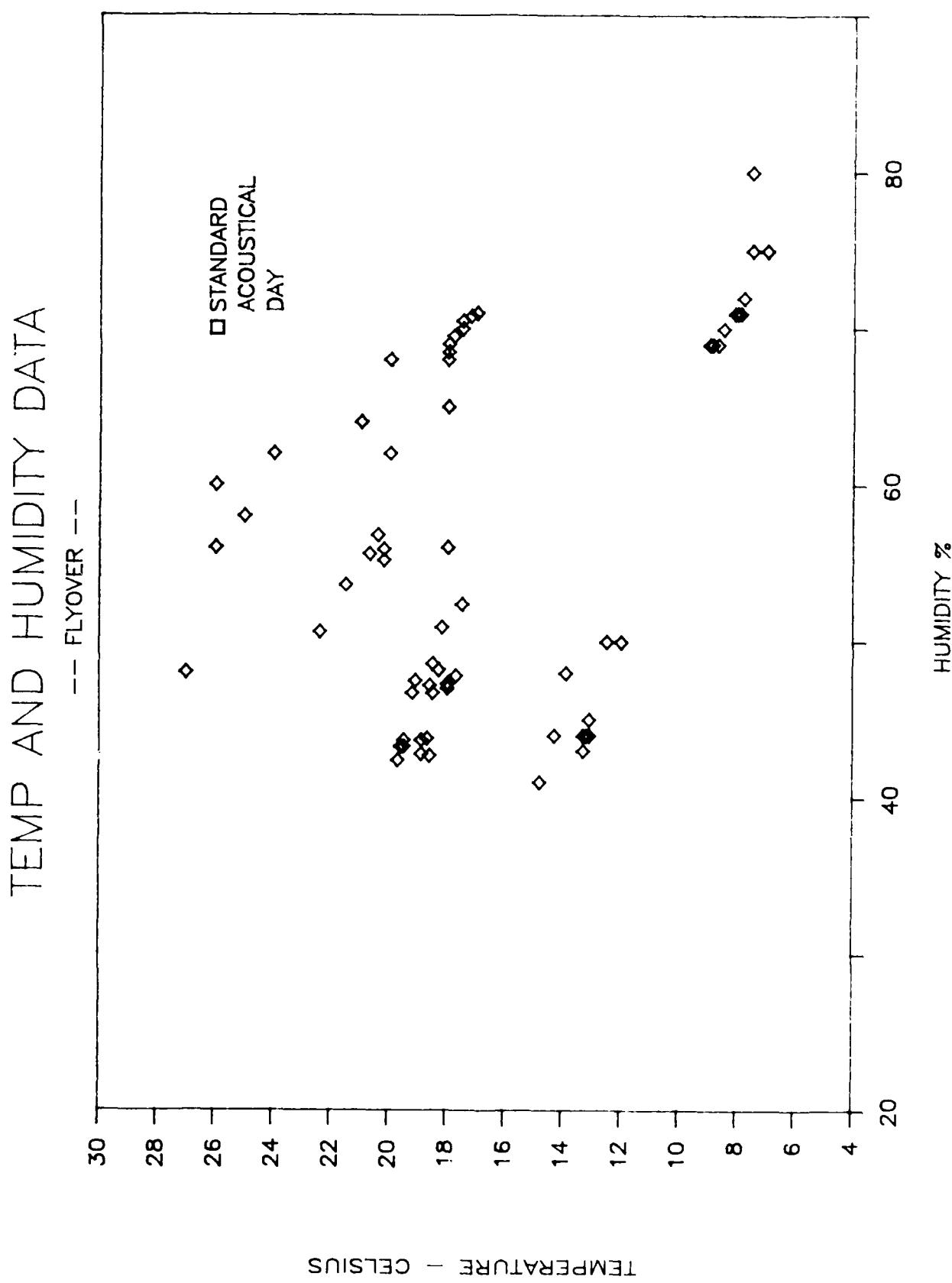


Figure 8.2.E



## 9.0 FURTHER ANALYSIS, EVALUATION AND INVESTIGATION

The HNMRP, from inception to the completion of this report, has spanned the years 1983 through 1987. During this time the program objectives were established and refined, field tests occurred, the data were analyzed and collated, findings were examined, and amendments to Annex 16 were developed and presented to WG II and CAEP/1. The HNMRP has thus, with this report, completed its program stage. However, the question, "Why are there differences?", is yet to be quantitatively addressed.

The following sections describe a sequence of steps for the continuation of the HNMRP investigation process. Section 9.1 is an outline of the HNMRP evaluation process; Section 9.2 discusses the issue of the data analysis system calibration test tapes; and Section 9.3 discusses the statistical considerations appropriate in the further study of the HNMRP data. (A list of prospective future work topics for ICAO Working Group II are listed in Section 10.0.)

### 9.1 A PROCESS FOR FURTHER EVALUATION OF HNMRP DATA

Presented below is the proposed evaluation process for the continued analysis, evaluation and investigation of HNMRP data.

#### Step 1: Normalization

The initial step should be to decide whether or not there are distinct reduction system biases that can be accounted for based on the results of the data analysis system calibration test tapes, discussed in Section 9.2. Subsequent application of this adjustment factor to the HNMRP data should account for data reduction system biases.

#### Step 2: Statistical Analysis of Single Event Participant Data

Next, determination of the appropriate single event data for each participant is necessary. This single event data is important for a proper scientific evaluation of the HNMRP data. Once participant single event data is identified, the data should be entered into the appropriate statistical analysis program, as discussed in Section 9.3, to evaluate whether or not differences in HNMRP data are statistically significant.

#### Step 3: Further Analysis Work

Following the statistical analysis of the single event HNMRP data, further analysis investigations outlined below, and listed in Section 10.0, should be examined.

#### Step 4: Evaluation and Investigation

Results of the various analyses should be examined and individual test programs should be further investigated to identify possible intrinsic source differences and/or elements of the testing process which can be identified as reasons for noise level dissimilarity. Areas for consideration include:

- 1) Meteorological Effects
  - a. temperature gradients
  - b. cross wind/on-track wind components
  - c. turbulence
  - d. crab angle
- 2) Data Corrections
  - a. source noise corrections
  - b. groundspeed duration corrections
  - c. distance duration corrections
  - d. spreading and absorption
- 3) Helicopter Operational Characteristics
  - a. Torque
  - b. Approach or takeoff profile (climb/descent angle)
  - c. airspeed
  - d. groundspeed
  - e. rotor RPM
- 4) Helicopter performance data resolution, acquisition, sampling and display techniques
- 5) Flight Control Stability Augmentation
- 6) Pilot Technique
- 7) Aircraft Specific Differences
  - a. maintenance history
  - b. hours on critical components
- 8) Methodology
  - a. Calibration
  - b. Gain Settings
  - c. Recording Instruments
  - d. Data Reduction Procedure
- 9) Helicopter Operational and Environmental Characteristics
  - a. Adherence to Reference Operational Conditions
  - b. Effects of Wind
- 10) Intrinsic Source Characteristics
  - a. Rotor blade track and balance

## 9.2 COMPARISON OF THE DATA REDUCTION SYSTEM CALIBRATION TEST TAPES

A calibration test tape exercise was incorporated in the HNM RP as a means to isolate data reduction system bias. Through normalizing reported data for the unique response of each participating analysis system one would expect to see more clearly the other sources of variation. Full implementation of this normalization process remains as an activity for the ICAO CAEP WG II (1987-1990).

The HNMRP was fortunate to have the assistance of Mr. E.J. Rickley (of the US DOT TSC), the coordinator of the 1980-1981 ICAO CAN Round-Robin Noise Analyzer Comparison Program, to serve as the focal point for the calibration tape exercise. The following paragraphs are abstracted, in part, from a summary paper prepared by Mr. Rickley for the Paris 1986 HNMRP evaluation meeting.

Calibration tapes, containing helicopter noise data events, were analyzed by the eight nations (ten laboratories) participating in the ICAO Helicopter Noise Measurement Repeatability Program (HNMRP). Identical tapes containing helicopter noise data events and calibration signals were prepared for use on Nagra instrumentation tape recorders. The tapes, after analysis on the U.S. system, were sent to the eight participating nations (ten laboratories) for analysis. The purpose of the exercise was to determine if biases due to instrumentation or calibration technique could be "calibrated out" when comparing individual results of the multi-nation helicopter noise measurement program.

The results indicate a natural grouping of the data by the type of analysis system used, with 0.28, 0.32, 0.32 dB standard deviations for the EPNL metric for the flyover, takeoff and approach events respectively. The standard deviations for the PNLT<sub>m</sub> metric were 0.26, 0.36, 0.32 dB, respectively.

These results generally agree with the results of the 1981 ICAO sponsored Helicopter Round Robin Test where data submitted by the ten participants produced standard deviations of 0.28, 0.32, 0.31 dB for the EPNL metric and 0.66, 0.57, 0.4 dB for the PNLT<sub>m</sub> metric for the flyover, takeoff and approach events, respectively.

The current data shown in Figures 9.2.A and 9.2.B have been grouped by type of analysis system used. It is noted that laboratories using the GR 1995 and B&K 2131 systems, with internal exponential averaging, produced results lower than the average, while those laboratories using the GR 1921 analyzer with external computer smoothing produced results higher than the average. The exception was with the laboratory that used the Rion SA-25 analysis system with internal exponential averaging which produced results higher than the average. This grouping by analyzer type was not obvious in the 1981 data for the EPNL metric but did show up in the PNLT<sub>m</sub> metric.

Several nations expressed concern with the "quality" (unsteady reference signal) of the calibration signal recorded on the test tapes. According to the recorder manufacturer, the cyclic amplitude fluctuations noted can be attributed to one or more of the following: worn or misaligned heads, improper tape hold-back tension, defective or worn tape guides, worn tension rollers or capstan pinch wheel, and/or defective capstan.

The two US recorders were completely overhauled by the manufacturer and aligned to the recommended 3m brand 177 tape prior to producing the test tapes. Amplitude fluctuations of less than 0.1 dB were noted for the calibration signal on these recorders.

A subsequent test of one nation's "suspect" test tape on the US recorder exhibited amplitude fluctuations of less than 0.1 dB; further, the results of a re-analysis of the helicopter events on the US system agreed within

Figure 9.2.A

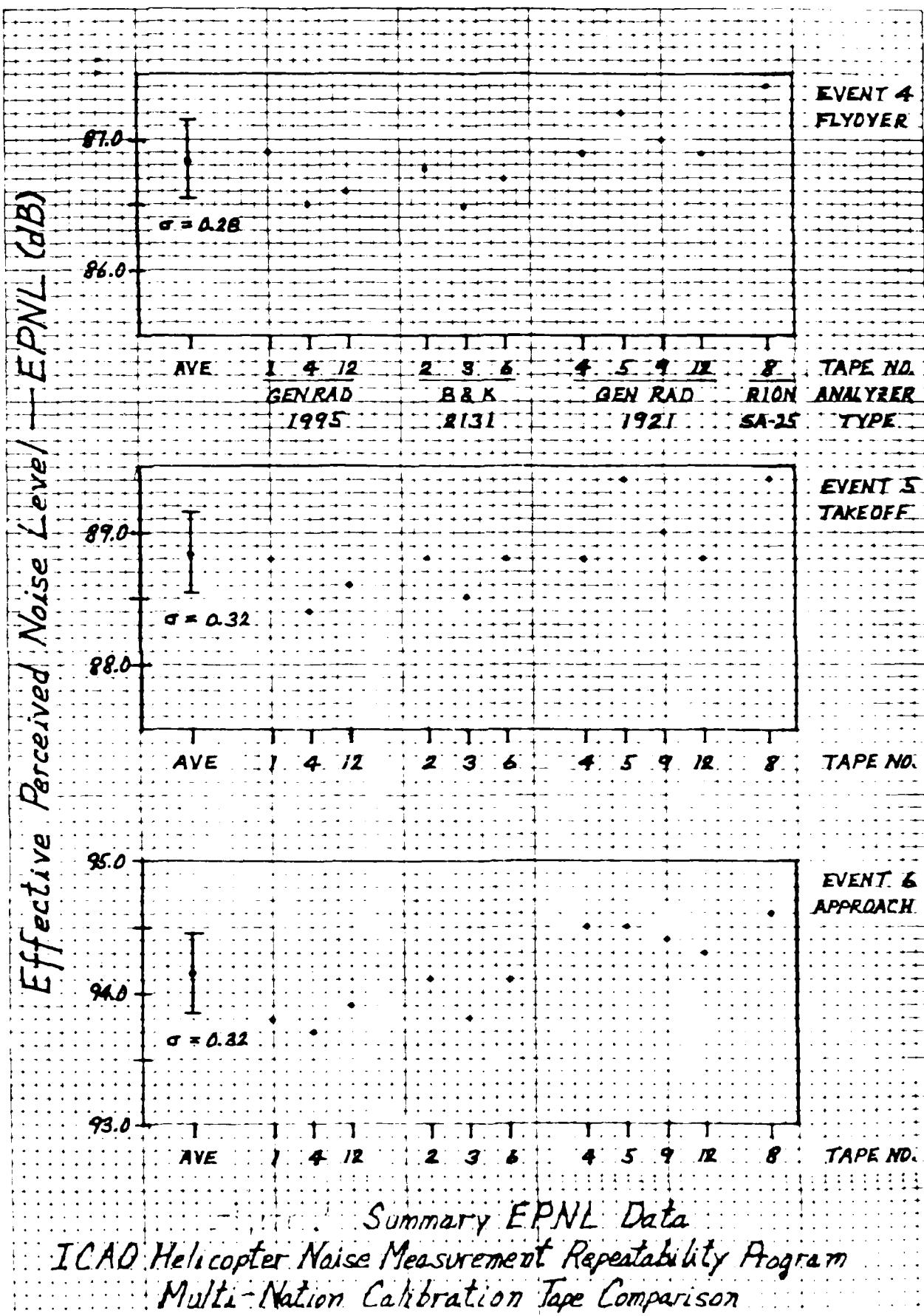
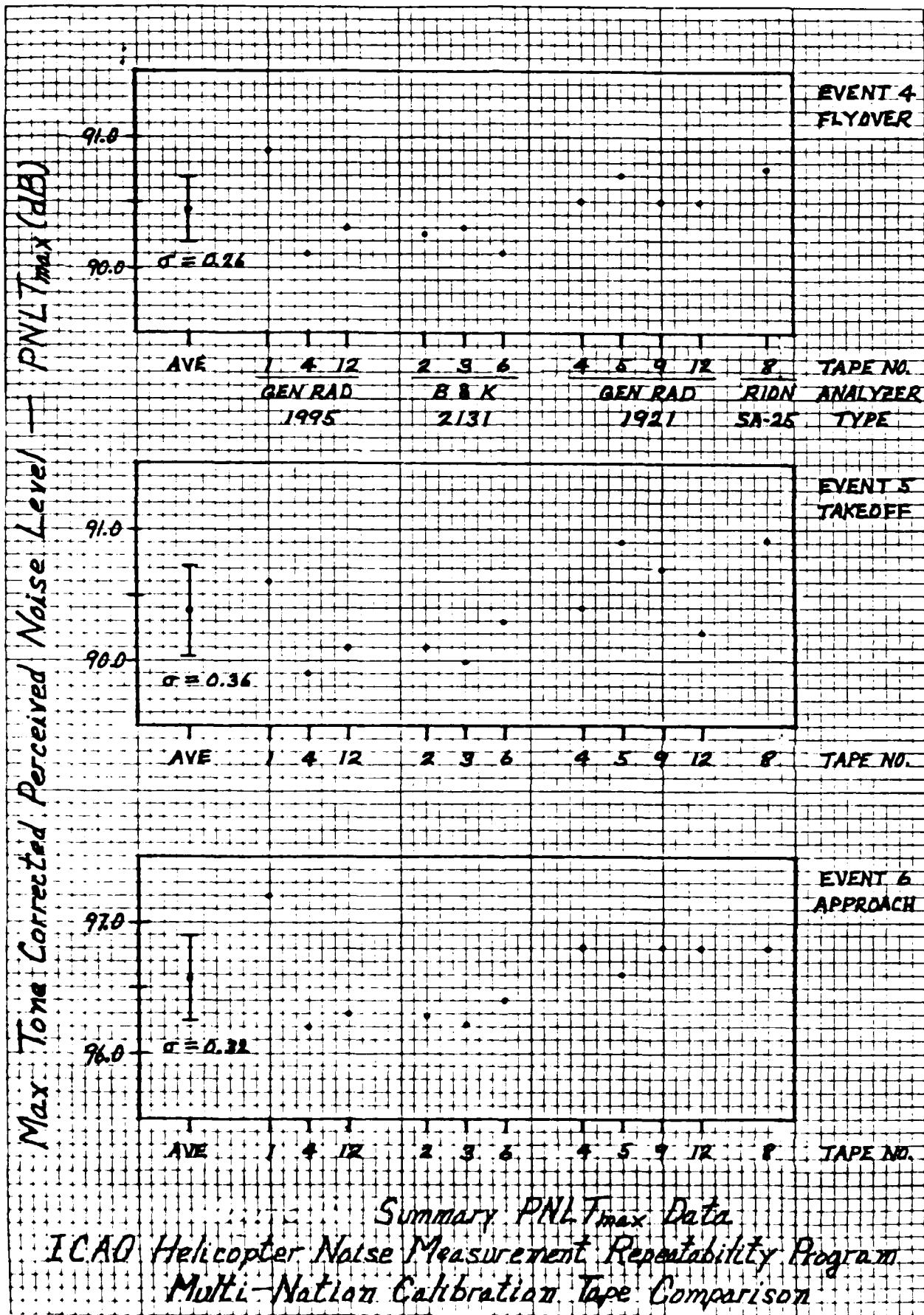


Figure 9.2.B



$\pm 0.1$  dB of the previous test of this tape by the US prior to shipment to the participant.

The US test tape (No. 12) was re-analyzed using five recorders including the two most recently overhauled and aligned Nagra recorders. The poorest reproduction of tape number 12 showed amplitude fluctuations of the calibration signal of  $\pm 0.3$  dB on one recorder. The amplitude fluctuations on the remaining four recorders was under  $\pm 0.2$  dB. Analysis of the helicopter events on tape number 12 on the US system using these five recorders, 3 reproductions each, produced a standard deviation of 0.1 dB in the EPNL and PNLT<sub>m</sub> metrics.

#### Observations

The natural grouping of the data by type of analysis system suggests a bias does exist between analysis system types. The GR 1921 system with external computer smoothing produced levels on the average 0.4 dB higher than those obtained from the GR 1995 and B&K 2131 systems with internal exponential averaging. The Rion SA-25 analyzer with internal exponential averaging produced levels on the average 0.6 dB higher than the GR 1995 and B&K 2131 systems.

#### Recommendations:

1. The HNRMP participants may consider adjusting final reported data by the following amounts to normalize for analysis system differences:
  - a) -0.4 dB should be applied to the GR-1921 produced data
  - b) -0.6 dB adjustment applied to the Rion SA-25 produced data.
2. Several participants raised the point that the higher levels from the GR-1921 system are an unexplained characteristic of this system. It is noted that this system has been declared obsolete by the manufacturer (last system sold in 1978). It is worth noting that much of the worldwide helicopter noise data base was established using the GR-1921. It may be prudent at this point, given the present high technology systems available, to recommend that the GR-1921 no longer be used.
3. It is further recommended that more stringent detector characteristics be imposed to insure slow scale exponential characteristics are applied especially when linear data is smoothed by external means.

At the CAEP 1 meeting in Montreal both recommendations 2 and 3 were adopted. Data adjustments, Recommendation 1, have been reserved as a future WG II (1987-1990) activity. At the Washington HNMMP evaluation meeting, the Program Coordinator's Staff had implemented data adjustments based on early Calibration Tape results. After a great deal of discussion, it was decided to proceed without implementing any adjustment until accord could be reached on the appropriateness of the corrections. Based in part, on that early controversy concerning amplitude instabilities of the calibration signal on some test tapes, an additional test was proposed by the U.K. delegation. E. J. Rickley's synopsis of that second exercise, is abstracted in part, below:

It was suggested by WG II in Ottawa (1985) that more could be learned and a more accurate normalization could be achieved if participants in the HNMMP would submit actual magnetic tape recordings of measured noise data from different flight operations for re-analysis on a single playback and reduction system in the US. A single participant, the UK, submitted an optional calibration tape with four helicopter noise data events.

The results of the UK and US processing of this tape is tabulated in Table 9.2.A. A comparison of the data, both processed with a GR-1995 analyzer, shows agreement within 0.2 dB or less for all metrics shown with the exception of the flyover, Event 2. Here a 0.4 dB difference in the tone correction calculation coupled with a 0.9 dB difference in PNLT<sub>m</sub> (which is being examined) results in a 0.3 dB difference in the EPNL metric. These results are in good agreement with a comparison of the UK and US data reduction of the multi-nation calibration tape where differences of 0.2 dB or less were observed for the EPNL and PNLT<sub>m</sub> metric measured with the GR-1995 analyzer.

Data processed by the US using the GR-1921 analyzer are provided in Table 9.2.A and show the GR-1921 data to be consistently higher than the data from the GR-1995 analyzer.

An interesting observation was made during the analysis of the UK optional calibration tape. Annex 16 specifies that a ripple of up to 0.5 dB is allowed in the pass band of a 1/3-octave filter (appendix 2, paragraph 3.4.2). A 0.3 dB ripple was measured for the 250 Hz filter in the GR-1995 analyzer. When the tape was processed using two different recorders a 0.3 dB bias was observed in the results using the GR-1995 analyzer. This was traced to the difference in speeds of the tape recorders (under 1%) which resulted in a change of 2 Hz in the 250 Hz calibration signal. This frequency shift was sufficient to move the calibration signal from the flat portion of the pass band to a peak and resulted in a 0.3 dB bias in all the data output.

#### Conclusions:

1. Comparison of the UK and US results using the GR-1995 analyzer are in excellent agreement both on the multi-nation calibration comparison and using the UK produced optional calibration tape. The bias of the GR-1921 system was again confirmed.
2. Subtle frequency changes coupled with filter pass band characteristics can account for up to 0.5 dB bias in data. This suggests that a closer than normal examination and/or adjustment of the 1/3-octave filter used for calibration of analyzers should be made.

The observations concerning calibration signal recording give one cause to consider a more rigorous requirement for the stability of signals in one-third octave bands, especially, the band in which the single frequency calibration signal is applied. The present 0.5 dB ripple allowance can, as demonstrated above translate to a 0.5 dB bias error in reported data. This topic is recommended for study and possible regulatory action at CAEP II, in 1990.

**Table 9.2.A**

EPNL and PNLT<sub>max</sub> Data  
ICAO Helicopter Noise Measurement Repetability Program  
Multi-Nation Calibration Tape Comparison

| <u>TAPE NO.</u>             | <u>PARTICIPANT</u> | <u>ANALYZER TYPE</u> | <u>EPNL(dB)</u> | <u>PNLT<sub>max</sub>(dB)</u> |
|-----------------------------|--------------------|----------------------|-----------------|-------------------------------|
| <u>Flyover Event No. 4</u>  |                    |                      |                 |                               |
| 1                           | Australia          | GEN RAD 1995         | 86.9            | 90.9                          |
| 4                           | UK-WHL             | " "                  | 86.5            | 90.1                          |
| 12                          | USA                | " "                  | 86.6            | 90.3                          |
| 2                           | Canada             | B&K 2131             | 86.77           | 90.26                         |
| 3                           | Italy              | " "                  | 86.48           | 90.31                         |
| 6                           | FRG                | " "                  | 86.7            | 90.1                          |
| 4                           | UK-BAE             | GEN RAD 1921         | 86.9            | 90.5                          |
| 5                           | F-Aerospatiale     | " "                  | 87.2            | 90.7                          |
| 9                           | F-STNA             | B&K 5090             | 87.0            | 90.5                          |
| 12                          | USA                | GEN RAD 1921         | 86.9            | 90.5                          |
| 8                           | Japan              | RION SA-25           | <u>87.37</u>    | <u>90.73</u>                  |
|                             |                    | AVE.                 | <u>86.85</u>    | <u>90.45</u>                  |
|                             |                    | STD. DEV.            | <u>0.28</u>     | <u>0.26</u>                   |
| <u>Takeoff Event No. 5</u>  |                    |                      |                 |                               |
| 1                           | Australia          | GEN RAD 1995         | 88.8            | 90.6                          |
| 4                           | UK-WHL             | " "                  | 88.4            | 90.9                          |
| 12                          | USA                | " "                  | 88.6            | 90.1                          |
| 2                           | Canada             | B&K 2131             | 88.81           | 90.09                         |
| 3                           | Italy              | " "                  | 88.51           | 90.98                         |
| 6                           | FRG                | " "                  | 88.8            | 90.3                          |
| 4                           | UK-BAE             | GEN RAD 1921         | 88.8            | 90.4                          |
| 5                           | F-Aerospatiale     | " "                  | 89.4            | 90.9                          |
| 9                           | F-STNA             | B&K 5090             | 89.0            | 90.7                          |
| 12                          | USA                | GEN RAD 1921         | 88.8            | 90.2                          |
| 8                           | Japan              | RION SA-25           | <u>89.43</u>    | <u>90.93</u>                  |
|                             |                    | AVE.                 | <u>89.85</u>    | <u>90.37</u>                  |
|                             |                    | STD. DEV.            | <u>0.32</u>     | <u>0.36</u>                   |
| <u>Approach Event No. 6</u> |                    |                      |                 |                               |
| 1                           | Australia          | GEN RAD 1995         | 93.8            | 97.2                          |
| 4                           | UK-WHL             | " "                  | 93.7            | 96.2                          |
| 12                          | USA                | " "                  | 93.9            | 96.3                          |
| 2                           | Canada             | B&K 2131             | 94.11           | 96.28                         |
| 3                           | Italy              | " "                  | 93.80           | 96.22                         |
| 6                           | FRG                | " "                  | 94.2            | 96.4                          |
| 4                           | UK-BAE             | GEN RAD 1921         | 94.5            | 96.8                          |
| 5                           | F-Aerospatiale     | " "                  | 94.5            | 96.6                          |
| 9                           | F-STNA             | B&K 5090             | 94.4            | 96.8                          |
| 12                          | USA                | GEN RAD 1921         | 94.3            | 96.8                          |
| 8                           | Japan              | RION SA-25           | <u>94.60</u>    | <u>96.67</u>                  |
|                             |                    | AVE.                 | <u>94.16</u>    | <u>96.57</u>                  |
|                             |                    | STD. DEV.            | <u>0.32</u>     | <u>0.32</u>                   |

### 9.3 STATISTICAL CONSIDERATIONS

#### 9.3.1 Statistical Treatment of Individual Team Results

For each mode of operation it was requested that at least six good flights be conducted. In each case, ICAO Annex 16 requires that the sample 90% confidence interval of the "three microphone average" must be less than 1.5 EPNdB.

The data tables submitted by participants displayed left, center, right, and "three-mic averaged" noise data, with arithmetic averages, standard deviation and 90% confidence intervals computed. (The "three-mic average" is the certification metric.) The left, center and right average values, along with the "3-mic" certification metric values, are summarized for each test team in Section 5 of this report.

#### 9.3.2 Statistical Analysis of Overall HNMRP Results

Determination of the statistical significance of all of the possible variance factors is an important part of the HNMRP process. One of the basic objectives of this structured repeatability test program was to define the intrinsic variability associated with the measurement of helicopter noise, related to the implementation of noise certification standards. It was anticipated that many random variables (difficult to compensate for when conducting helicopter certification noise programs) could contribute to variations in certification noise-level measurements. It was also anticipated that biases, if identified, may be amenable to adjustment, and if appropriately addressed could result in improved accuracy in certification measurement capabilities. Identification and quantification of both random and non-random sources of variation represent the ultimate objective in the HNMRP evaluation process.

Controllable variables which were identified included:

1. noise data acquisition system characteristics,
2. ground surface characteristics,
3. variable meteorological conditions, and
4. helicopter maintenance.

Other unconstrained variables included:

1. production line factors (i.e., manufacturing tolerances, instrument accuracy, etc.)
2. pilot technique (i.e., consistency of helicopter attitude, smoothness of control)
3. micro-meteorological influences (i.e., temperature-humidity variation, small scale turbulence)

#### 9.3.3 Statistical Procedures

The statistical procedures briefly identified below were those discussed and accepted by HNMRP participants as being appropriate for evaluating similarity of HNMRP sample means and variances. A detailed description of each technique

along with examples was provided in the "Helicopter Noise Measurement Repeatability Program Mid-Program Review--Advance Phases Protocol" (Ref 5).

TEST FOR EQUIVALENCY OF VARIANCES: BARTLETT'S TEST

This test examines the equivalency of variances of multiple samples. It is a prerequisite for using the standard "Analysis of Variance" test (below). If this test determines that the variances are not statistically similar then a test more complicated than the "Analysis of Variance" test is required.

TEST FOR EQUIVALENCY OF MEANS: ANALYSIS OF VARIANCE

This test examines the equivalency of means for multiple samples.

TEST FOR EQUIVALENCY OF TWO VARIANCES: F TEST

This test examines the equivalency of variances for samples of two. This test is a prerequisite for using the "Students-t" test (below). If this determines that the variances are not statistically similar, a test more complicated than the "Students-t" test is required.

TEST FOR EQUIVALENCY OF TWO MEANS: STUDENTS "T" TEST (or just "t-Test")

This test examines the equivalency of means for two independent samples.

In order to implement these statistical tests it is necessary to use the actual individual event data from each test program. To test the similarity of the multi-nation takeoff PNLT<sup>m</sup> variances, for example, it is necessary to include PNLT<sup>m</sup> for each event measured by each team, a minimum of 48 (eight teams times 6 runs each) values. It is evident that the sheer volume of data and time required to sort individual event data (not to mention the difficulty in pulling data from different formats) precluded the implementation of "significance testing" at this time.

A methodology, however, was developed which allows the reader some insight into the statistical significance of differences. This procedure estimates whether or not a difference in means is significant for any given paired comparison. The procedure involves the use of the nomograph shown in Figure 9.3.A, which was developed through interactively exercising the Students-t test. It is important to note, however, that the standard deviations of the two samples to be compared must be approximately equal. If this condition is met, all that is necessary is to locate the difference in means on the ordinate of the graph and then move right to the point intersecting the appropriate standard deviation value. If the point of intersection is above the line then the null hypothesis is rejected, i.e., the difference in means is considered statistically significant.

## 10.0 FUTURE WORK TOPICS

This section lists future work items which have been identified during the HNMRP. They are natural follow-on work topics for consideration by ICAO Working Group II and the ICAO Technical Manual Committee. These lists represent a compendium of possible activity areas identified by HNMRP participants and do not represent proposed policy of the FAA or any other certificating authority.

### 10.1 FUTURE ANALYSIS OF HNMRP DATA

This first group of future work topics are analyses which involve further study of HNMRP data. It is anticipated that these analyses will provide more knowledge concerning the individual sources of variation associated with the noise certification process.

- 1 Perform statistical analysis of results - implement paired and group comparisons of sample variance and means as discussed in Section 9.3, Statistical Considerations. The results of these analyses should be examined in reference to the pilot to pilot, test day to test day, and other repeatability questions.
- 2 Investigate wind influences - analyze the relationship between wind speed and direction and changes in sample variance.
- 3 Quantify and compare the magnitude of the Delta 1, 2, and 3 correction values in the various test programs and investigate why reference trajectory conditions were not attained in some cases.
- 4 Study differences in reported source noise adjustment functions.
- 5 Investigate overflight noise level variability - specifically whether level flyover data variability is related to test procedures or some other factor.
- 6 Examine the time between overhaul status of the HNMRP test vehicles - analyze possible intrinsic source differences, that is the variation from one serial helicopter to the next.
- 7 Investigate and resolve various inter-program team to team differences, including a more thorough investigation of the France-Italy-US program and an investigation of the UK-FRG tracking data results (where the same type of tracking system was used by each team).
- 8 Explore differences between RION analyzer calibration tape results and the others reported.
- 9 Examine the results attained with the normal incidence microphones (used in the Japanese test program) as compared to the pressure-sensitive type microphones, specifically reviewing the ground versus 1.2m microphone data.

SECTION 10.2 FUTURE TOPICS FOR REGULATORY REFINEMENT AND IMPLEMENTATION GUIDANCE

The following are proposed analyses which step beyond the HNMRP data.

- 1 Examine the variation in sideline elevation angle Psi.
- 2 Study speed control on approach and the influence of speed variation on noise levels.
- 3 Examine the use of the following method to compensate for pressure altitude variations from the sound level reference condition.

$$Cp' = \frac{P'\text{measured}}{(\rho_0 a_0^2)\text{measured}} = \frac{P'\text{norm}}{(\rho_0 a_0^2)\text{norm}}$$

$Cp'$  = nondimensional acoustic pressure coefficient

$$P'\text{norm} = \frac{(\rho_0 a_0^2)\text{norm}}{(\rho_0 a_0^2)\text{measured}} \times P'\text{measured}$$

$\rho_0$  = ambient density

$$P'\text{norm} = \frac{(\rho_0)\text{norm}}{(\rho_0)\text{measured}} \times P'\text{measured}$$

$P_0$  = ambient pressure

$a_0$  = ambient speed of sound

norm = normalized to standard day s.l.

- 4 Investigate use of parameter "carpets", multi-parameter sensitivity curves.
- 5 Further explore noise analyzer standardization especially in view of the B&K detector response differences recently observed in Europe.
- 6 Explore total revision of the takeoff test to achieve greater compatibility with airworthiness requirements for takeoff rather than the existing climbout tie-in. This would involve a direct climb takeoff from a hover operation. Acquire a data base for this operation at a variety of measurement sites.
- 7 Determine whether or not a better correlate exists for implementing source noise adjustments than advancing blade tip Mach number.
- 8 Conduct a cost analysis of the proposed experimental 3-6-9 degree approach certification scheme.
- 9 Re-examine A-109 differences within the context of "lessons learned" in the HNMRP.
- 10 Open up the repeatability "questions" to other repeat test helicopters for which good documentation is available (S-76, Dauphin SA 365N, Twin Star SA 355, Bell 222, Bell 206L).
- 11 Develop realistic and reasonable no correction window constraints for future Appendix 4 amendments.
- 12 Re-evaluate regulatory stringency - which should involve tracking the progress of NASA, DFVLR and other research organizations working on helicopter noise prediction.

- 13 Consider a "small helicopter" simplified certification testing procedures.
- 14 Examine cross referencing in Chapter 8 with Appendix 4 - review structural consistency within certification scheme and attempt to simplify the format.
- 15 Introduce a sensitivity curve requirement for ground speed duration correction for level flyover.
- 16 Revise reference temperature structure for each operation - ambient air temperature of 15 degrees Celsius, i.e., ISA or ISA + 10 degrees Celsius, as specified by the reference operation procedures in Sections 8.6.2, 8.6.3, and 8.6.4.
- 17 Review and restructure the WC II "Summary of Helicopter Noise Data", data base - develop an "electronic spreadsheet" or computer data base format.
- 18 Notify the IEC concerning ICAO CAEP-1 dynamic response modifications.

#### SECTION 10.3 NOISE CERTIFICATION HANDBOOK GUIDANCE

The following list identifies proposed topics for inclusion in a helicopter noise certification handbook.

- 1 Tracking systems.
- 2 Requirements for source noise adjustments.
- 3 Requirements for takeoff operation rotation point determination.
- 4 Determination of reference trajectory and position information.
- 5 Flight deck data acquisition and documentation instrumentation.
- 6 Approach guidance techniques.
- 7 Implementation of alternative approach operations (3 and 9 degree operations). Explain various techniques to deploy and redeploy approach guidance instrumentation and/or acoustical instrumentation in an efficient manner to maintain the prescribed reference altitude.
- 8 Develop a compendium of information which realistically describes the costs associated with helicopter noise certification testing. Analyze in-house costs verses the cost of using an acoustical consultant.
- 9 Incorporate information which would be useful in developing noise exposure curves (for use in noise contouring computer models) from flight test data.
- 10 Provide information on data stream time synchronization, identifying problems encountered in one of the HNMRP test programs.



## REFERENCES

1. Helicopter Noise Analysis -- Round Robin Test  
Report FAA-EE-81-13, E.J. Rickley: US DOT, August 1981
2. "An Examination of Test to Test Variability for the A109A Helicopter Using ICAO Annex 16 Noise Certification Procedures:  
Paper presented jointly by the German, Italian, and US Working Group B (WG B) members at the January 1983 ICAO CAN WG B meeting.
3. "Report of WG II to CAEP/1"  
Paper presented by the Rapporteur of WG II at the ICAO CAEP/1 meeting June 1986, Montreal, Canada.
4. "Test Plan for the ICAO Helicopter Noise Measurement Repeatability Program"  
Paper presented by the HNMRP Program Coordinator to ICAO WG II members in November of 1983, revised and redistributed December 15, 1983.
5. "Mid-Program Review--Advanced Phase Protocol"  
Paper presented by the HNMRP Program Coordinator to HNMRP participants in October of 1984.
6. "ICAO Annex 16"  
International Standards and Recommended Practices,  
"Environmental Protection"  
Annex 16 to the Convention on International Civil Aviation Published by the International Civil Aviation Organization
7. Bell 206L-1 Long Ranger II Flight Manual  
Published by Bell Helicopter Textron, May 18, 1978
8. "Compendium of Comments on the HNMRP Test Plan"  
Paper presented by the HNMRP Program Coordinator at the May 1984 ICAO WG II meeting in Boston, USA.
9. Letter from UK HNMRP participant to the HNMRP Program Coordinator, January 16, 1984  
Letter references:
  - A. Analysis of Helicopter Noise - An Area of Concern", May 1981 UK ICAO CAN WP 10
  - B. "Specification of Noise Analysis Equipment for Helicopter Noise Certification", December 1981 UK ICAO CAN WP 2
  - C. "Analyzer Crest Factor Limitations", E. Rickley, October 1981 DOT-TSC-FA-253-LR-2
10. ICAO Committee on Aircraft Noise Seventh Meeting Montreal, 2-13 May 1983 Report  
Doc 9419, CAN/7, International Civil Aviation Organization

11. "Determination of Minimum Distance from Ground Observer to Aircraft for Acoustic Tests"  
SAE Reports AIR-902, May 15, 1966
12. "Paris PC Paper #5"  
Paper distributed to HNMRP participants as part of the "Data and Papers for Paris" in regards to the PARIS HNMRP Evaluation Meeting in April of 1986.
13. "Paris PC Paper #6"  
Paper distributed to hnmp participants as part of the "Data and Papers for Paris" in regards to the PARIS HNMRP Evaluation Meeting in April of 1986.

Participants' Submittals  
(most recent submittal listed first)

AUSTRALIA:

1. Amendments for Multi-Nation Report, June, 1986
2. Tabular results, April, 1986
3. Preliminary Report Data, January 1986
4. "Best 6" Corrected EPNL & PNLTm Data Telex, September 1985
5. Reanalyzed Calibration Tape Results Telex, August 1985
6. Book A, The Australian Report, March 1985
7. Book B, the Australian Report, March 1985
8. First Results Report, February 1985
9. Calibration Tape Data, 1985

CANADA:

1. Final Report Mark-up, September 1986
2. The Canadian Report, April 1986
3. Post October Meeting Response, November 1985
4. Corrected EPNL & PNLTm Data, September 1985
5. As Measured Data, August 1985
6. Calibration Tape #2 Results, June 1985
7. Preliminary Data Results, September 1984

FEDERAL REPUBLIC OF GERMANY:

1. Final Report Mark-up, September 1986
2. Additional Corrected DAta, July 1986
3. Post October Meeting Report, December 1985
4. The German Report, August 1985
5. As Measured Data, March 1985

Participants' Submittals Continued

FRANCE - AEROSPACE:

1. Final Numbers Telex, March 14, 1986
2. Final Report Notes, September 1986
3. Final Report, April 1986
4. Summary Report, April 1986
5. Measurement Results, April 1986
6. Preliminary Report, April 1986
7. Preliminary Synthesis Reports, March 1986

FRANCE - STNA:

1. Telex confirming Data, November 1986
2. Final Report Notes and February Cover, January 1987
3. February Cover and Letter, January 1987
4. Post October Meeting Response, December 1986
5. December Cover Page with Letter, August 1987
6. Book II: Preliminary Data, August 1987
7. Book I: Preliminary Data, August 1987

JAPAN:

1. Fully Corrected Data Report, May 1986
2. Japan Report, September 1986
3. Preliminary Report, March 1986

UNITED KINGDOM:

1. Final Report Notes, September 1986
2. The UK Report, September 1986
3. Calibration Tape Analysis Results, March 1986

Participants' Submittals Continued

4. Initial Data Package
5. Westland Helicopter Ltd. Report, December 1985

UNITED STATES:

1. ICAO HNMRP: US Test Report, Bell 206L-1 Noise Measurement Flight Test  
Report No. FAA-EE-85-6, September 1985

HNMRP PAPERS

(includes limited distribution data and information papers)

1. "Test Plan for the ICAO HNMRP", December 1983  
Distributed to WG II members.
2. "Compendium of Comments on the HNMRP Test Plan", May 1984  
ICAO WG II Boston Meeting BIP.
3. "Mid Program Review--Advance Phase Protocol", October 1984  
Distributed to HNMRP participants.
4. "Data in Hand Summary", July 1985  
Distributed to HNMRP participants.
5. "Second Distribution of Data", August 1985  
Distributed to HNMRP participants.
6. "Helicopter Noise Certification Test Procedures", March 1985  
ICAO WG II Tokyo Meeting WP #6.
7. "Data Processing and Analysis Topics:", March 1985  
ICAO WG II Tokyo Meeting WP #7.
8. "Phase 4 - Statistical Treatment of HNMRP Results", March 1985  
ICAO WG II Tokyo Meeting BIP #14.
9. "HNMRP Washington Evaluation Meeting Package", October 1985  
Distributed to HNMRP participants.

Included in this package were papers presented by  
the Program Coordinator on the following topics:

EVALUATION PROCESS  
CALIBRATION TAPE ANALYSIS  
STATISTICAL NOMOGRAPH  
EPNL MULTI-NATION SYNTHESIS  
OBSERVATIONS  
2 TEAM COMPARISON  
4 TEAM COMPARISON  
ONE TEAM AT TWO DIFFERENT TESTS  
LEFT RIGHT DIRECTIVITY  
PNLTm VERSUS ADVANCING BLADE TIP MACH NUMBER  
1.2 METER VERSUS GROUND MIC  
AIR TO GROUND PROPAGATION  
STATIC ANALYSIS  
PARTICIPANT REPORTS

HNMRP PAPERS CONTINUED

10. HNMRP Washington Evaluation Meeting Participant Papers:

"Beyond the Flight Tests: Suggestions for a Logical Treatment of the Noise Data:, Presented by the UK.

Papers were presented by France on the following topics:

APPROACH, SLOW RESPONSE - QUICK RESPONSE  
GROUND ABSORPTION  
TAKEOFF TRAJECTORY  
AEROSPATIALE FLYOVER RESULTS  
CALIBRATION BAND

11. "Proceedings from the ICAO HNMRP Washington Evaluation Meeting", November 1985. Distributed to HNMRP participants.

12. "Data and Papers for Paris", April 1986.  
Distributed to HNMRP participants.

Included in the package were the following papers:

|                            |              |   |
|----------------------------|--------------|---|
| PC PAPER 1                 | TECH ADVISOR | Multinational Calibration Tape  |
| PC PAPER 2                 | PC           | Detector Response   |
| PC PAPER 3                 | PC           | Deviation in Elevation Angle PSI<br>Viewed From Sideline Sites  |
| PC PAPER 4                 | PC           | Takeoff Correction Window   |
| PC PAPER 5                 | TECH ADVISOR | Proposed Reference Power Setting For<br>Takeoff and Landing   |
| PC PAPER 6                 | TECH ADVISOR | Future Restructure of Takeoff Test<br>Procedures  |
| PC PAPER 7                 | PC           | Evaluation of the No-correction<br>Window   |
| FRANCE 11-2-86 FRANCE      |              | Proposal for an Acoustically<br>Acceptable Method of Noise Level<br>Adjustment Measured With Lateral<br>Microphones for Helicopter<br>Certification |
| PARIS LAST MIN ADD UK & US |              | Optional Calibration Tape<br>Comparison Data  |

**ICAO Working Group II (WG II) Meeting  
Working Papers (WP)  
and  
Background Information Papers (BIPS)**

| MEETING      | PAPER  | SUBMITTED BY | TITLE  |
|--------------|--------|--------------|--|
| WG II BOSTON | BIP    | US           | Compendium of Comments on Test Plan  |
| WG II TOKYO  | BIP 5  | US           | US/Canadian Test Program - US Status   |
| WG II TOKYO  | BIP 14 | HNMRP PC     | Phase 4 - Statistical Treatment of HNMRP Results   |
| WG II TOKYO  | BIP 15 | JAPAN        | Preliminary Report on Japanese Test Results  |
| WG II TOKYO  | BIP 20 | CANADA       | HNMRP Canadian Participation & Status of Data Reduction  |
| WG II TOKYO  | BIP 21 | FRANCE       | Helicopter Noise Measurement Repeatability   |
| WG II TOKYO  | WP 5   | HNMRP PC     | Multi-nation Status  |
| WG II TOKYO  | WP 6   | HNMRP PC     | Helicopter Noise Certification Testing Procedures<br>Topics: Level Flyover Testing Requirements, Repeatability Program Problem Areas, Rotor Speed          |
| WG II TOKYO  | WP 7   | HNMRP PC     | Data Processing and Analysis<br>Topics: Atmospheric Absorption Layering Requirements, Dynamic Response Requirements For Analyzers Source Noise Adjustments |
| WG II OTTAWA | BIP 1  | HNMRP PC     | Program Coordinator's Report   |
| WG II OTTAWA | BIP 1  | FRANCE       | Comments on Amendment Proposed For CH 9,9.5: Correction of Noise at Source   |
| WG II OTTAWA | BIP 11 | UK           | Revised Takeoff Procedure  |
| WG II OTTAWA | BIP 12 | UK           | Dynamic Response Requirements for Analyzer   |

**APPENDIX A**  
**SUMMARY MULTI-NATION COMPARISON NOISE DATA**

The contents of Appendix A are as follows:

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|--|----|
| EPNL Metric Multi-nation Comparison Data.....              | 3  |
| Takeoff Operation  |    |
| Summary Comparison Table.....                              | 4  |
| 3-Mic Average Scatter Plot.....                            | 5  |
| Source Directivity Plots.....                              | 6  |
| Approach Operation   |    |
| Summary Comparison Table.....                              | 9  |
| 3-Mic Average Scatter Plot.....                            | 10 |
| Source Directivity Plots.....                              | 11 |
| Level Flyover Operation      UK delta 3 calculated at 15°C |    |
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| 3-Mic Average Scatter Plot.....                            | 13 |
| Source Directivity Plots.....                              | 14 |
| PNLTM Metric Multi-nation Comparison Data.....             | 18 |
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| Summary Comparison Table.....                              | 19 |
| 3-Mic Average Scatter Plot.....                            | 20 |
| Source Directivity Plots.....                              | 21 |
| Approach Operation   |    |
| Summary Comparison Table.....                              | 23 |
| 3-Mic Average Scatter Plot.....                            | 24 |
| Source Directivity Plots.....                              | 25 |
| Level Flyover Operation      UK delta 3 calculated at 15°C |    |
| Summary Comparison Table.....                              | 26 |
| 3-Mic Average Scatter Plot.....                            | 27 |
| Source Directivity Plots.....                              | 28 |
| SEL Metric Multi-nation Comparison Data.....               | 32 |
| Takeoff Operation  |    |
| Summary Comparison Table.....                              | 33 |
| 3-Mic Average Scatter Plot.....                            | 34 |
| Source Directivity Plots.....                              | 35 |
| Approach Operation   |    |
| Summary Comparison Table.....                              | 38 |
| 3-Mic Average Scatter Plot.....                            | 39 |
| Source Directivity Plots.....                              | 40 |

|  |  |  |
|--|--|--|
| <b>Level Flyover Operation</b>                   | UK delta 3 calculated at 15 <sup>o</sup> C |  |
| Summary Comparison Table.....                    | 41   |  |
| 3-Mic Average Scatter Plot.....                  | 42   |  |
| Source Directivity Plots.....                    | 43   |  |
| <br>Alm Metric Multi-nation Comparison Data..... | 46   |  |
| <br><b>Takeoff Operation</b>                     |  |  |
| Summary Comparison Table.....                    | 47   |  |
| 3-Mic Average Scatter Plot.....                  | 48   |  |
| Source Directivity Plots.....                    | 49   |  |
| <br><b>Approach Operation</b>                    |  |  |
| Summary Comparison Table.....                    | 52   |  |
| 3-Mic Average Scatter Plot.....                  | 53   |  |
| Source Directivity Plots.....                    | 54   |  |
| <br><b>Level Flyover Operation</b>               | UK delta 3 calculated at 15 <sup>o</sup> C |  |
| Summary Comparison Table.....                    | 55   |  |
| 3-Mic Average Scatter Plot.....                  | 56   |  |
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| <br><b>Duration Time Data</b> .....              | 60   |  |
| <br><b>Duration P</b>                            |  |  |
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| Approach.....                                    | 64   |  |
| Level Flyover.....                               | 66   |  |
| <br><b>Duration A</b>                            |  |  |
| Takeoff.....                                     | 69   |  |
| Approach.....                                    | 71   |  |
| Level Flyover.....                               | 73   |  |

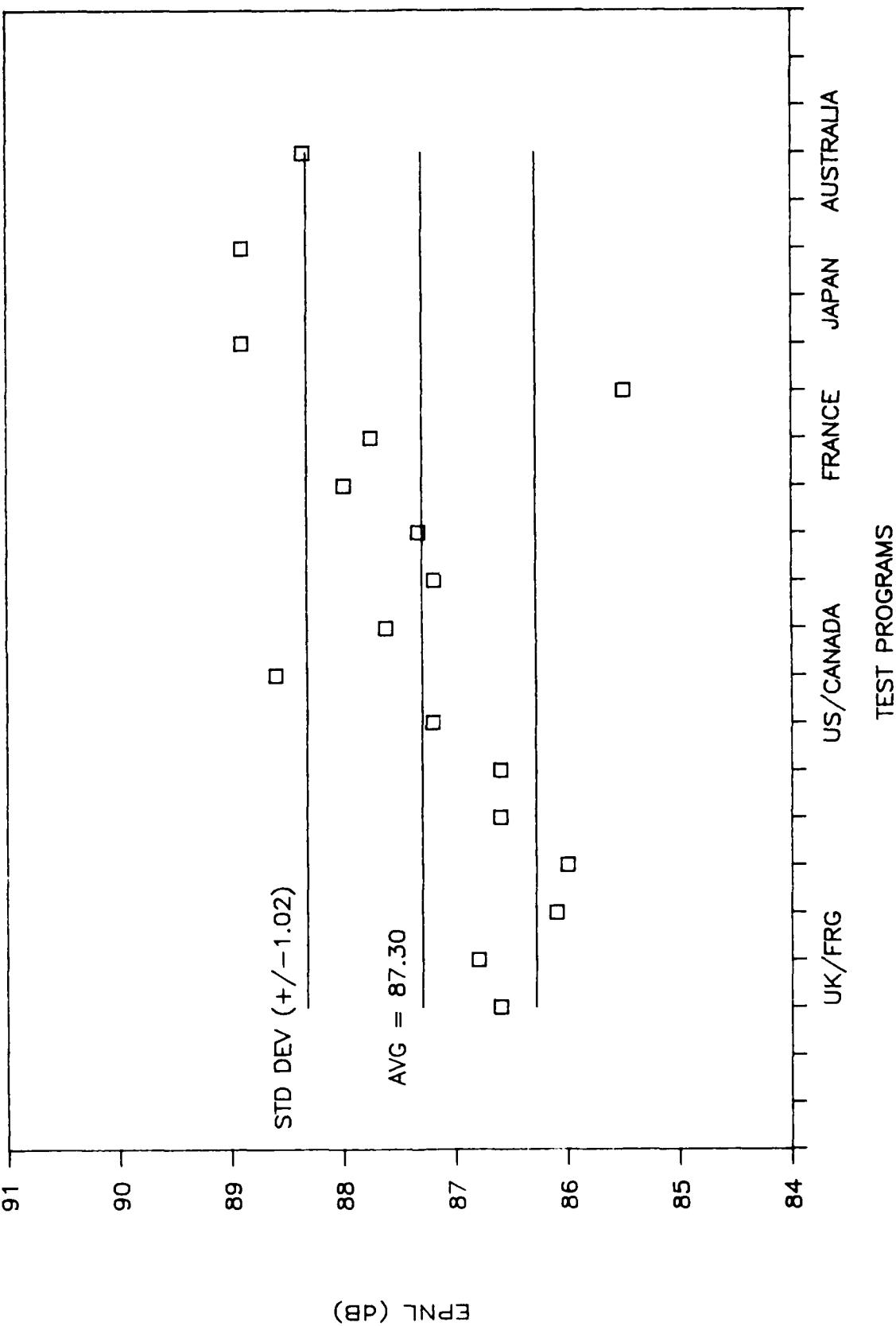
Please note that all UK level flyover data was corrected with a delta 3 correction referenced to 15 degrees C. All other teams used delta 3 corrections referenced to 25 degrees C.

# **EPNL Metric Multi-nation Comparison Data**

MULTI-NATION COMPARISON ANALYSIS  
TAKE-OFF EPNL DATA EXPRESSED IN DECIBELS (dB)

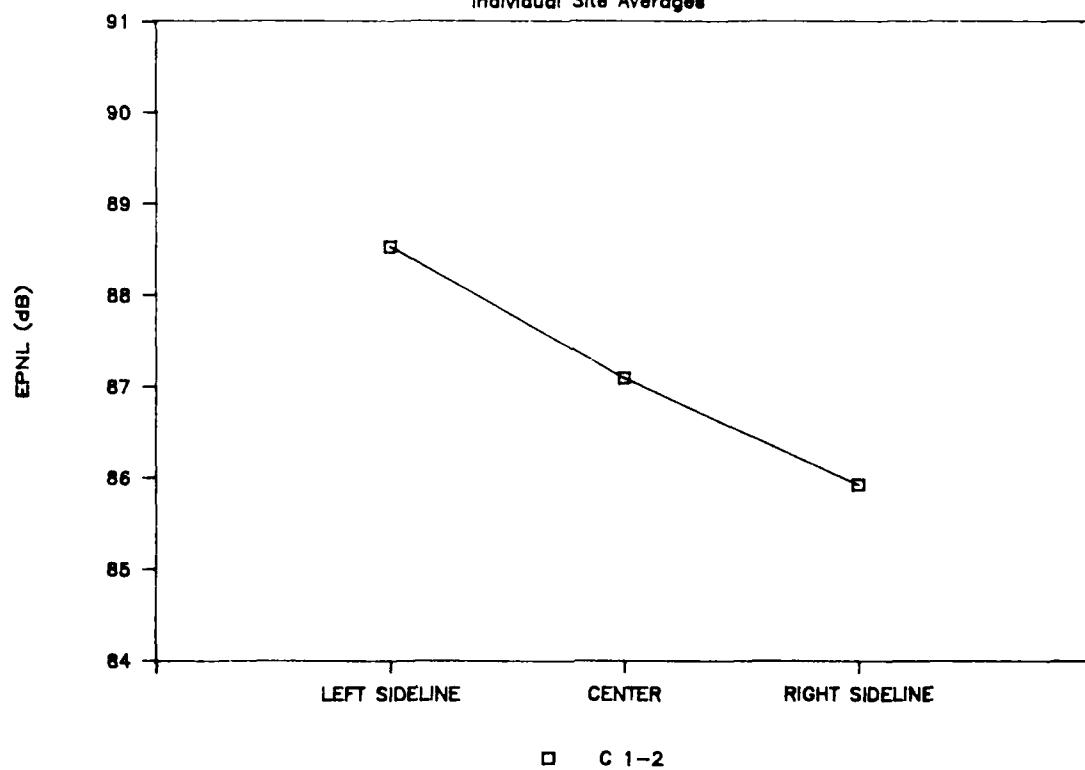
| PARTICIPANT      | LEFT                | CENTER            | LINE                | RIGHT           | 3 MIC<br>AVERAGE | STD<br>DEV | 90% C.I. | TEAM            | TEST            |
|------------------|---------------------|-------------------|---------------------|-----------------|------------------|------------|----------|-----------------|-----------------|
|                  | SIDELINE<br>AVERAGE | CENTER<br>AVERAGE | SIDELINE<br>AVERAGE | TEAM<br>AVERAGE |                  |            |          | TEAM<br>AVERAGE | TEST<br>AVERAGE |
| AUSTRALIA        | 87.89               | 89.55             | 87.63               | 88.35           | 0.39             | 0.17       | 88.35    | 88.35           |                 |
| JAPAN-PILOT 1    | 88.80               | 88.90             | 88.90               | 88.90           | 0.30             | 0.20       | 88.90    | 88.90           |                 |
| JAPAN-PILOT 2    | 88.10               | 90.00             | 88.70               | 88.90           | 0.50             | 0.30       | 88.90    |                 |                 |
| FRANCE-AERO      | 85.70               | 88.40             | 87.40               | 87.20           | 0.64             | 0.53       | 87.20    | 86.35           |                 |
| FRANCE-STNA      | 84.70               | 87.30             | 84.50               | 85.50           | 0.40             | 0.30       | 85.50    |                 |                 |
| ITALY            | NA                  | NA                | NA                  | NA              | NA               | NA         | NA       |                 |                 |
| FRG-PILOT 1      | 85.50               | 86.60             | 86.10               | 86.10           | 0.30             | 0.30       | 86.05    | 86.38           |                 |
| FRG-PILOT 2      | 86.30               | 85.70             | 86.20               | 86.00           | 0.10             | 0.00       | 86.70    |                 |                 |
| UK-PILOT 1       | 86.00               | 87.30             | 86.60               | 86.60           | 0.40             | 0.30       | 86.70    |                 |                 |
| UK-PILOT 2       | 86.40               | 86.60             | 87.20               | 86.80           | 0.20             | 0.20       |          |                 |                 |
| CANADA-PILOT 1-1 | 87.76               | 87.35             | 87.75               | 87.62           | 0.17             | 0.29       | 87.53    | 87.39           |                 |
| CANADA-PILOT 1-2 | 88.54               | 87.10             | 85.93               | 87.19           | 0.08             | 0.35       |          |                 |                 |
| CANADA-PILOT 2-1 | 87.79               | 88.16             | 86.03               | 87.33           | 0.86             | 1.45       |          |                 |                 |
| CANADA-PILOT 2-2 | 86.96               | 89.35             | 87.65               | 87.99           | 0.92             | 1.56       |          |                 |                 |
| US-PILOT 1-1     | 86.90               | 86.70             | 86.20               | 86.60           | 0.31             | 0.21       | 87.25    |                 |                 |
| US-PILOT 1-2     | 87.40               | 86.40             | 85.90               | 86.60           | 0.25             | 0.23       |          |                 |                 |
| US-PILOT 2-1     | 87.30               | 87.70             | 86.50               | 87.20           | 0.59             | 0.44       |          |                 |                 |
| US-PILOT 2-2     | 89.00               | 89.40             | 87.30               | 88.60           | 0.63             | 0.52       |          |                 |                 |
| AVERAGE          | 87.12               | 87.79             | 86.85               | 87.26           | 0.41             | 0.43       | 87.19    | 87.47           |                 |
| STD DEV          | 1.22                | 1.28              | 1.11                | 1.02            | 0.25             | 0.42       | 1.12     | 1.15            |                 |
| 90% C.I.         | 0.77                | 0.80              | 0.70                | 0.64            | 0.15             | 0.27       | 1.19     | 1.93            |                 |

EPNL 3 MIC AVERAGE & STD DEVIATION  
TAKEOFF



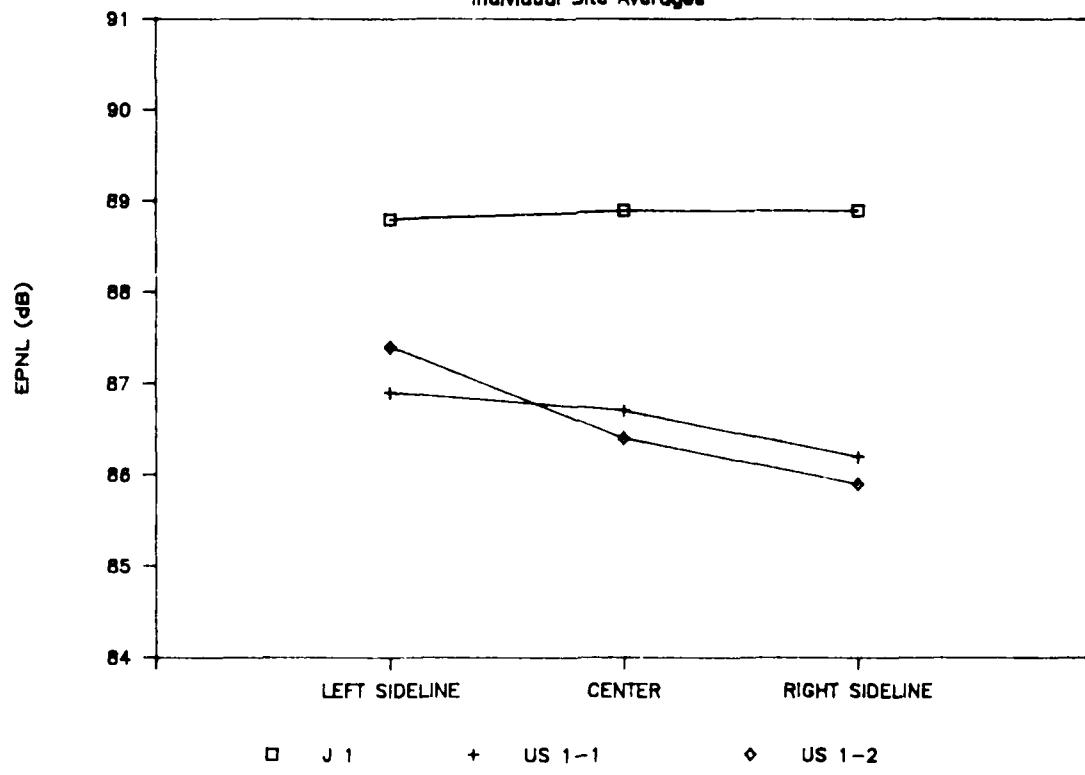
### EPNL-TAKEOFF

Individual Site Averages



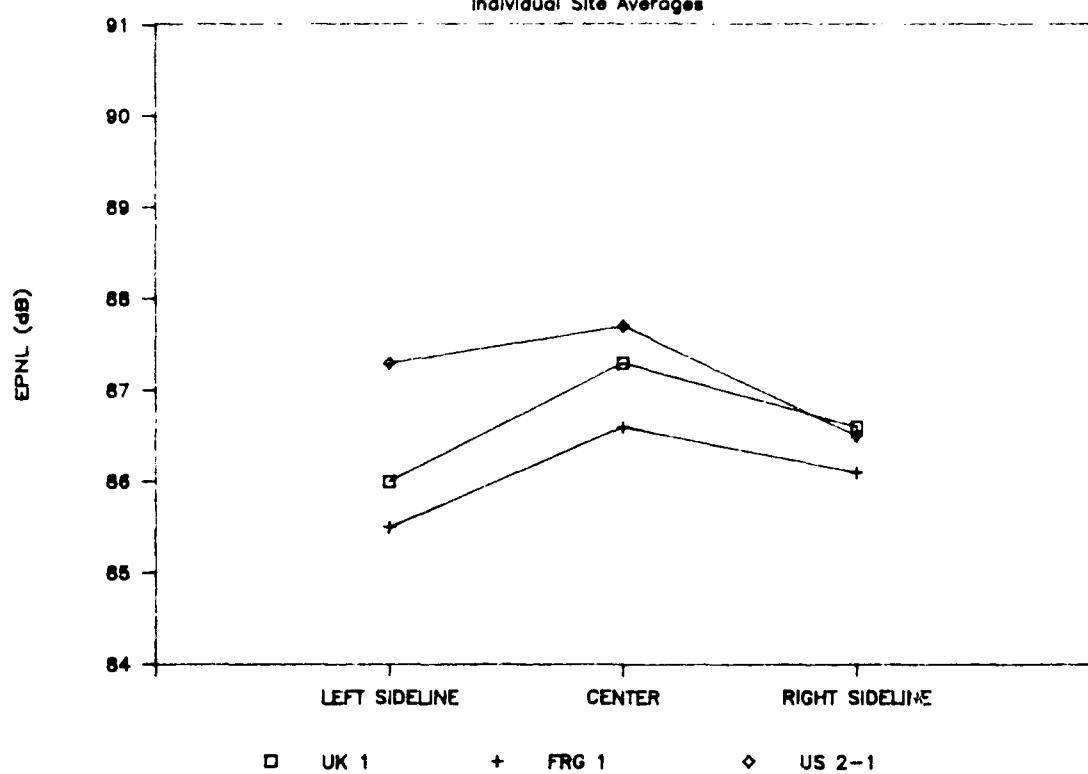
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Individual Site Averages



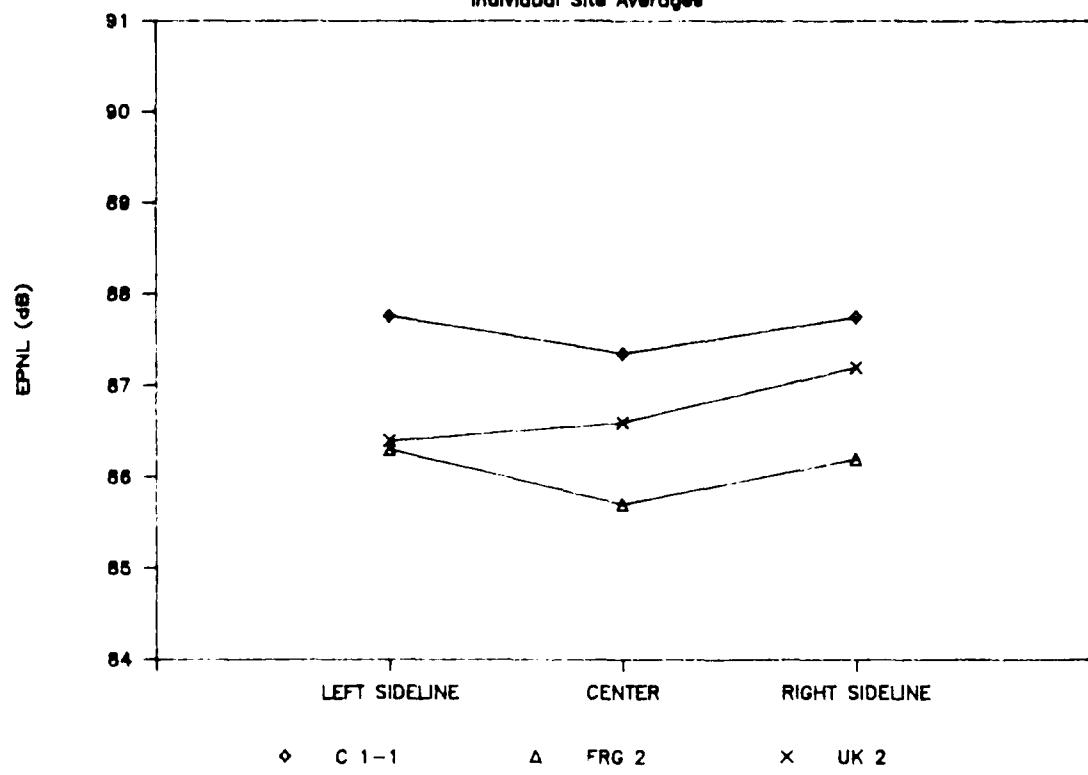
### EPNL-TAKEOFF

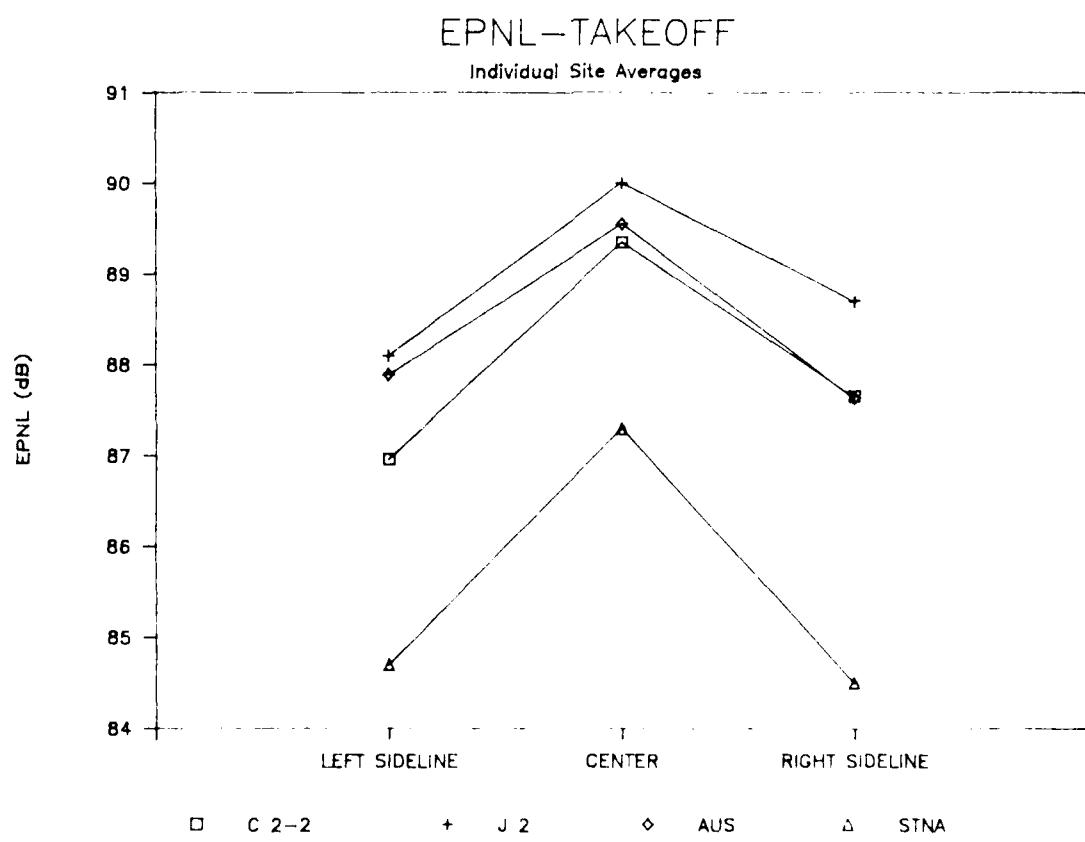
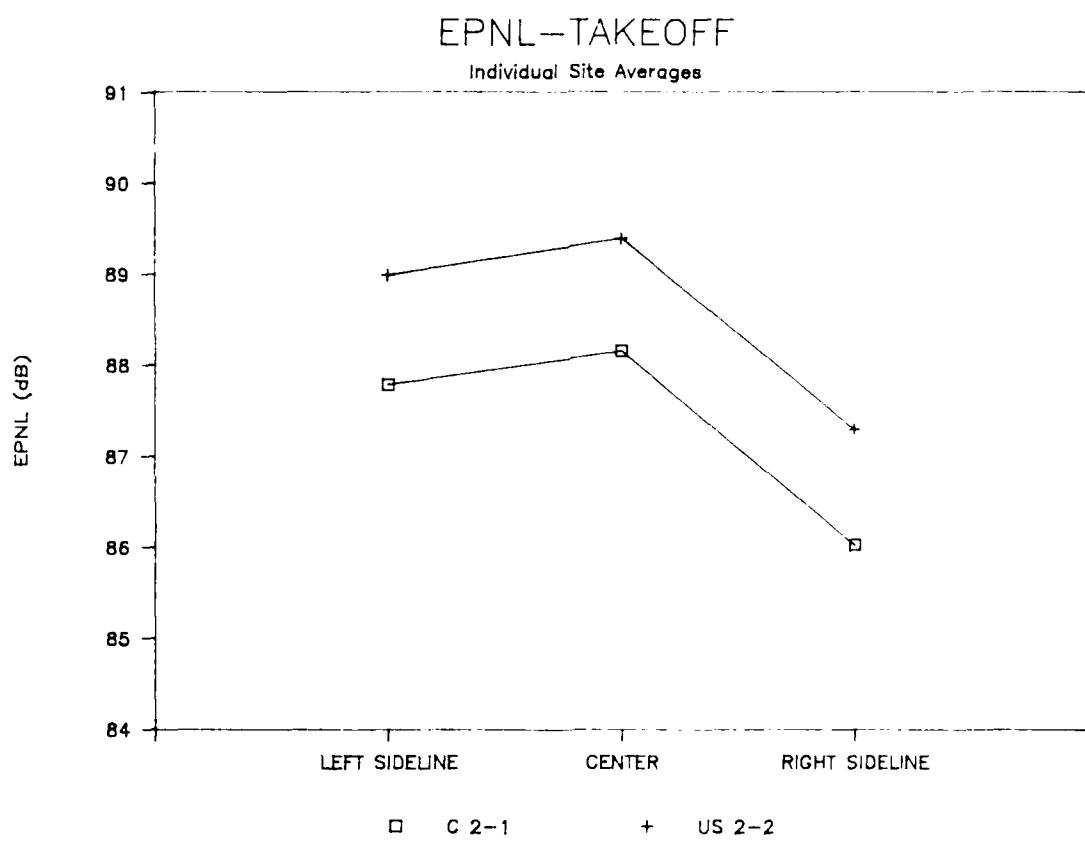
Individual Site Averages



### EPNL-TAKEOFF

Individual Site Averages

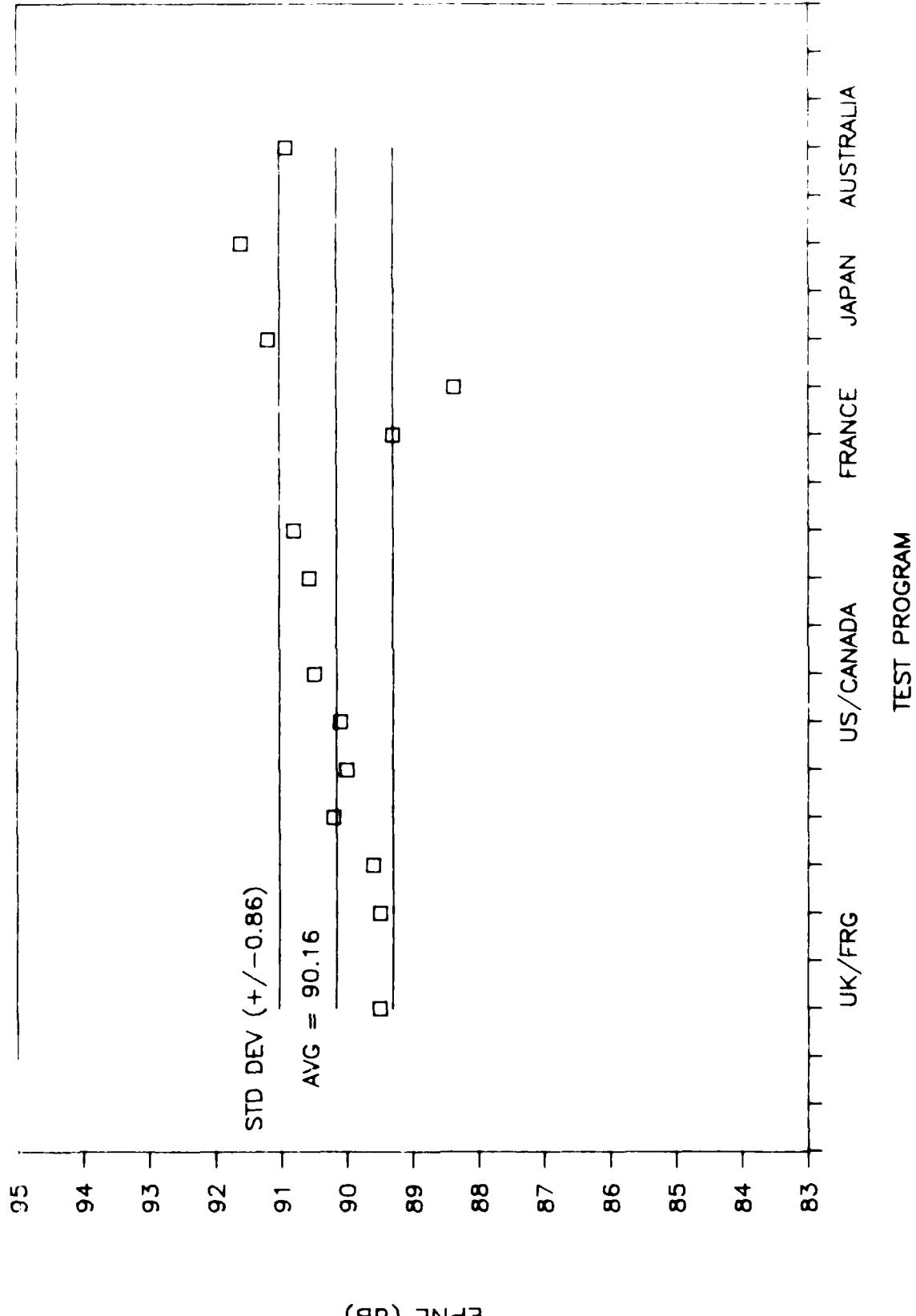




MULTI-NATION COMPARISON ANALYSIS  
APPROACH EPNL DATA EXPRESSED IN DECIBELS (dB)

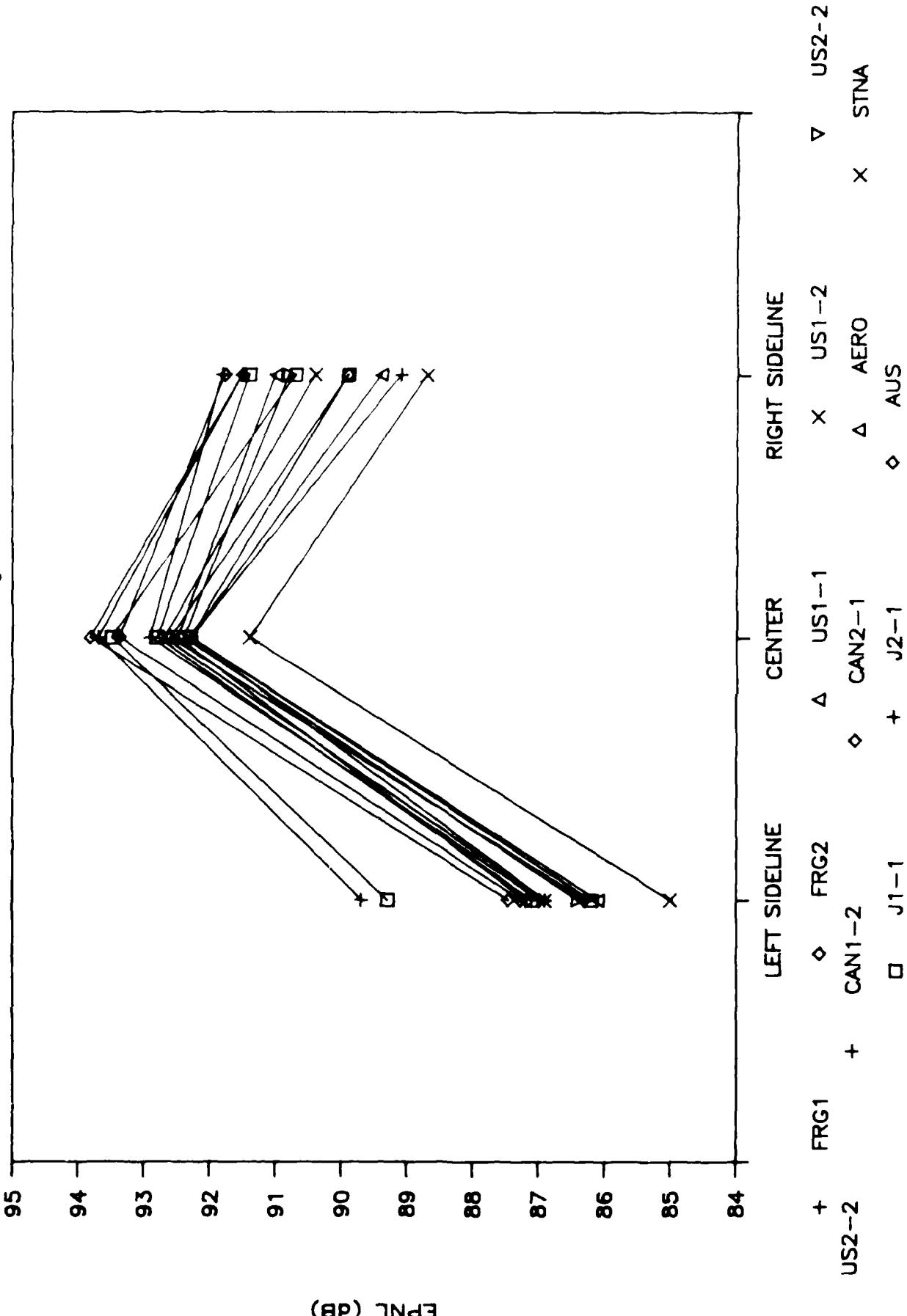
| PARTICIPANT      | LEFT<br>SIDELINE<br>AVERAGE | CENTER LINE<br>CENTER<br>AVERAGE | RIGHT<br>SIDELINE<br>AVERAGE | 3 MIC<br>AVERAGE | STD<br>DEV | 90% C.I. | TEAM<br>AVERAGE | TEET<br>AVERAGE |
|------------------|-----------------------------|----------------------------------|------------------------------|------------------|------------|----------|-----------------|-----------------|
| <hr/>            |                             |                                  |                              |                  |            |          |                 |                 |
| AUSTRALIA        | 87.46                       | 93.82                            | 91.51                        | 90.90            | 0.98       | 0.88     | 91.40           | 91.90           |
| JAPAN-PILOT 1    | 89.30                       | 93.50                            | 90.70                        | 91.20            | 0.87       | 0.87     | 91.40           | 91.40           |
| JAPAN-PILOT 2    | 89.70                       | 93.70                            | 91.50                        | 91.60            | 0.90       | 0.81     |                 |                 |
| FRANCE-AERO      | 86.10                       | 92.30                            | 89.40                        | 89.30            | 0.84       | 1.41     | 89.70           | 89.94           |
| FRANCE-STNA      | 85.00                       | 91.40                            | 88.70                        | 89.77            | 0.80       | 0.41     | 89.77           |                 |
| ITALY            | NA                          | NA                               | NA                           | NA               | NA         | NA       | NA              |                 |
| FRG-PILOT 1      | 86.90                       | 92.30                            | 89.10                        | 89.50            | 0.60       | 0.40     | 89.55           | 89.55           |
| FRG-PILOT 2      | 86.30                       | 92.60                            | 89.90                        | 89.50            | 0.50       | 0.40     |                 |                 |
| UK-PILOT 1       | 86.20                       | 92.30                            | 89.90                        | 89.50            | 0.50       | 0.40     | 89.50           |                 |
| CANADA-PILOT 1-2 | 86.97                       | 92.92                            | 91.81                        | 90.57            | 0.17       | 0.58     | 91.59           | 91.16           |
| CANADA-PILOT 2-1 | 87.27                       | 93.38                            | 91.77                        | 90.81            | 0.81       | 1.63     |                 |                 |
| US-PILOT 1-1     | 87.20                       | 92.50                            | 91.00                        | 90.20            | 0.55       | 0.40     | 90.20           |                 |
| US-PILOT 1-2     | 86.90                       | 92.70                            | 90.40                        | 90.00            | 0.41       | 0.39     |                 |                 |
| US-PILOT 2-1     | 86.40                       | 92.40                            | 90.80                        | 90.10            | 0.71       | 0.51     |                 |                 |
| US-PILOT 2-2     | 87.10                       | 92.80                            | 91.40                        | 90.50            | 0.52       | 0.75     |                 |                 |
| <hr/>            |                             |                                  |                              |                  |            |          |                 |                 |
| AVERAGE          | 87.06                       | 92.76                            | 90.56                        | 90.16            | 0.61       | 0.58     | 89.99           | 90.21           |
| STD DEV          | 1.21                        | 0.66                             | 1.02                         | 0.86             | 0.21       | 0.20     | 1.00            | 1.04            |
| 90% C.I.         | 0.86                        | 0.47                             | 0.73                         | 0.61             | 0.15       | 0.21     | 1.06            | 1.74            |

EPNL 3 MIC AVERAGE & STD DEVIATION  
APPROACH



# EPNL-APPROACH

## Individual Site Averages



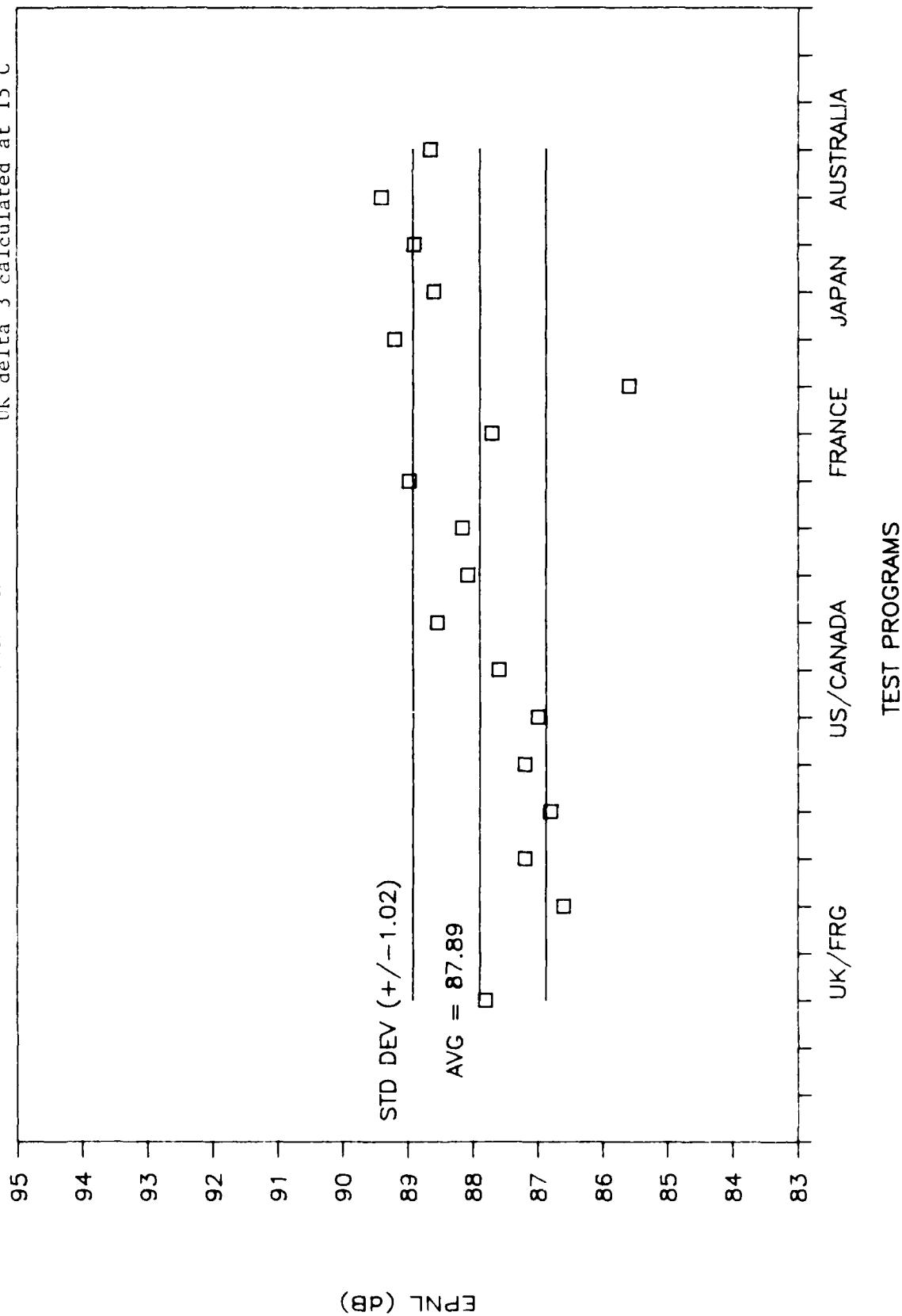
MULTI-NATION COMPARISON ANALYSIS  
LEVEL FLYOVER EPNL DATA EXPRESSED IN DECIBELS (dB)

| PARTICIPANT      | LEFT                 | CENTER            | LINE                 | RIGHT                | 3 MIC<br>AVERAGE | STD<br>DEV | 90% C.I. | TEAM<br>AVERAGE | TEST<br>AVERAGE |
|------------------|----------------------|-------------------|----------------------|----------------------|------------------|------------|----------|-----------------|-----------------|
|                  | SIDE LINE<br>AVERAGE | CENTER<br>AVERAGE | SIDE LINE<br>AVERAGE | SIDE LINE<br>AVERAGE |                  |            |          |                 |                 |
| AUSTRALIA        | 88.82                | 89.69             | 87.42                | 88.65                | 0.72             | 0.39       | 88.65    | 88.65           |                 |
| JAPAN-PILOT 1-1  | 90.10                | 89.10             | 88.40                | 89.20                | 0.40             | 0.50       | 89.03    | 89.03           |                 |
| JAPAN-PILOT 1-2  | 90.90                | 88.20             | 86.80                | 88.60                | 0.40             | 0.70       |          |                 |                 |
| JAPAN-PILOT 2-1  | 90.40                | 88.40             | 87.90                | 88.90                | 0.60             | 0.70       |          |                 |                 |
| JAPAN-PILOT 2-2  | 91.50                | 89.10             | 87.70                | 89.40                | 0.40             | 0.50       |          |                 |                 |
| FRANCE-AERO      | 87.80                | 88.40             | 86.80                | 87.70                | 0.36             | 0.43       | 87.70    | 86.65           |                 |
| FRANCE-STNA      | 85.30                | 87.50             | 87.90                | 85.60                | 0.40             | 0.50       | 85.60    |                 |                 |
| ITALY            | NA                   | NA                | NA                   | NA                   | NA               | NA         | NA       |                 |                 |
| FRG-PILOT 1      | 86.60                | 88.20             | 84.90                | 86.60                | 0.30             | 0.20       | 86.80    | 87.20           |                 |
| FRG-PILOT 2      | 86.30                | 89.70             | 85.60                | 87.20                | 0.30             | 0.30       |          |                 |                 |
| UK-PILOT 1       | 89.10                | 89.00             | 85.20                | 87.80                | 0.25             | 0.21       | 87.80    |                 |                 |
| CANADA-PILOT 1-1 | 88.59                | 88.67             | 88.34                | 88.54                | 0.22             | 0.21       | 88.44    | 87.79           |                 |
| CANADA-PILOT 1-2 | 88.55                | 88.38             | 87.29                | 88.07                | 0.58             | 0.68       |          |                 |                 |
| CANADA-PILOT 2-1 | 87.61                | 88.77             | 88.12                | 88.16                | 0.46             | 2.06       |          |                 |                 |
| CANADA-PILOT 2-2 | 89.42                | 88.58             | 88.94                | 88.98                | 0.43             | 0.51       |          |                 |                 |
| US-PILOT 1-1     | 87.30                | 86.80             | 86.30                | 86.90                | 0.29             | 0.21       | 87.15    |                 |                 |
| US-PILOT 1-2     | 87.70                | 87.70             | 86.30                | 87.20                | 0.16             | 0.19       |          |                 |                 |
| US-PILOT 2-1     | 87.30                | 87.50             | 86.20                | 87.00                | 0.30             | 0.25       |          |                 |                 |
| US-PILOT 2-2     | 88.60                | 87.00             | 87.30                | 87.60                | 0.45             | 0.30       |          |                 |                 |
| AVERAGE          | 88.43                | 88.37             | 86.86                | 87.89                | 0.39             | 0.49       | 87.66    | 87.86           |                 |
| STD DEV          | 1.83                 | 0.83              | 1.35                 | 1.02                 | 0.14             | 0.43       | 1.11     | 0.99            |                 |
| 90% C.I.         | 0.99                 | 0.50              | 0.82                 | 0.52                 | 0.09             | 0.26       | 1.17     | 1.65            |                 |

FK delta 3 calculated at 15°C

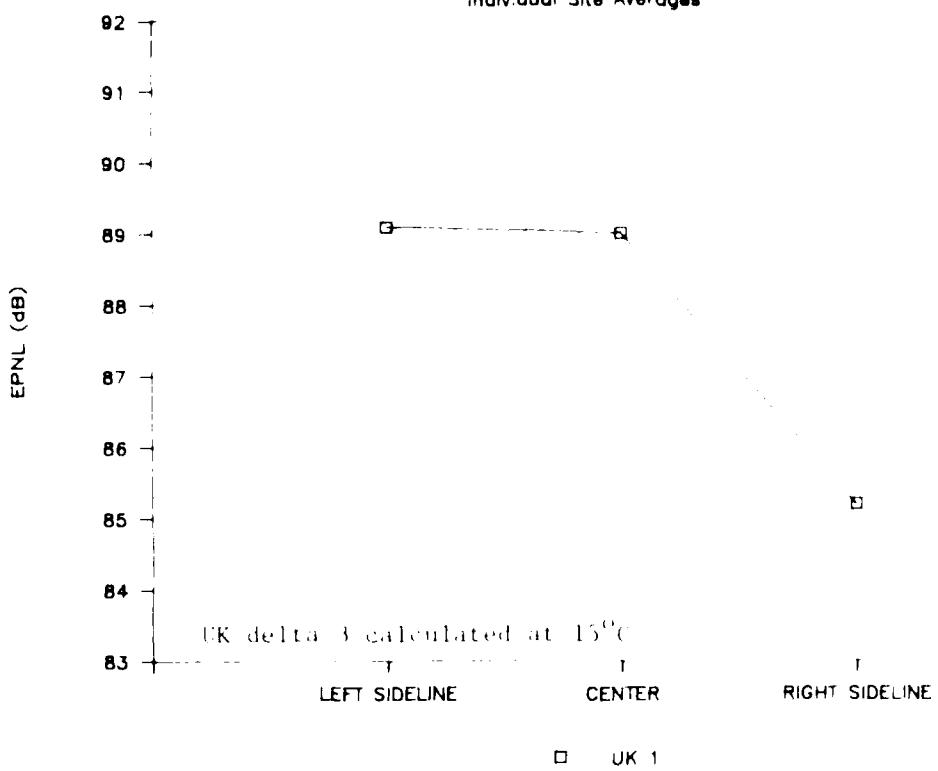
# EPNL 3 MIC AVERAGE & STD DEVIATION

FLYOVER      UK delta 3 calculated at 15°C



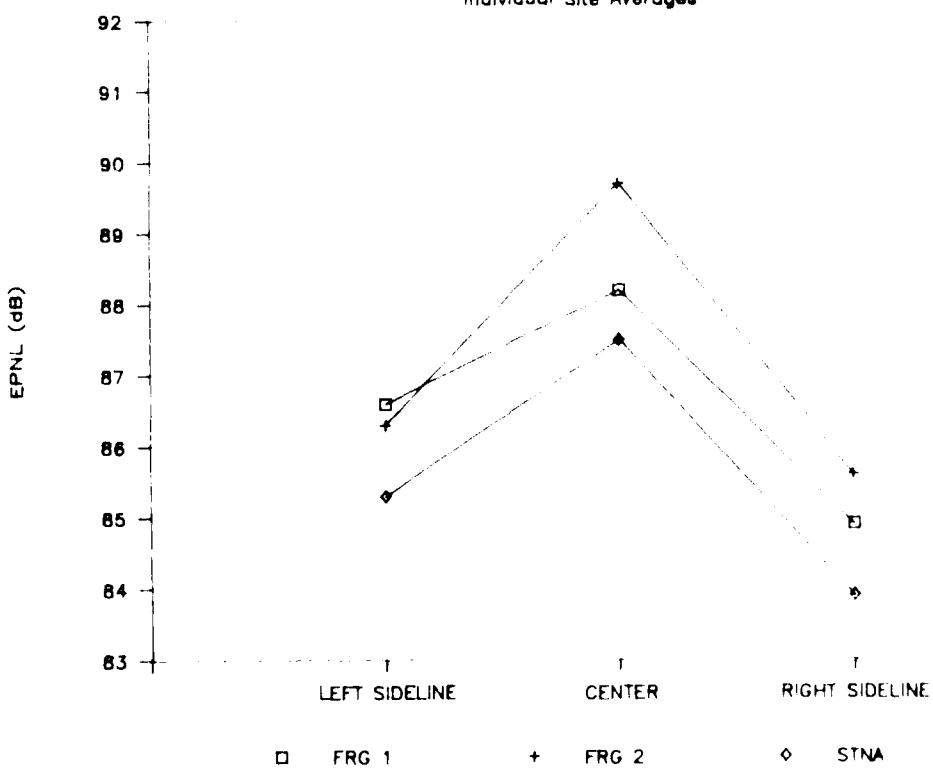
### EPNL-FLYOVER

Individual Site Averages



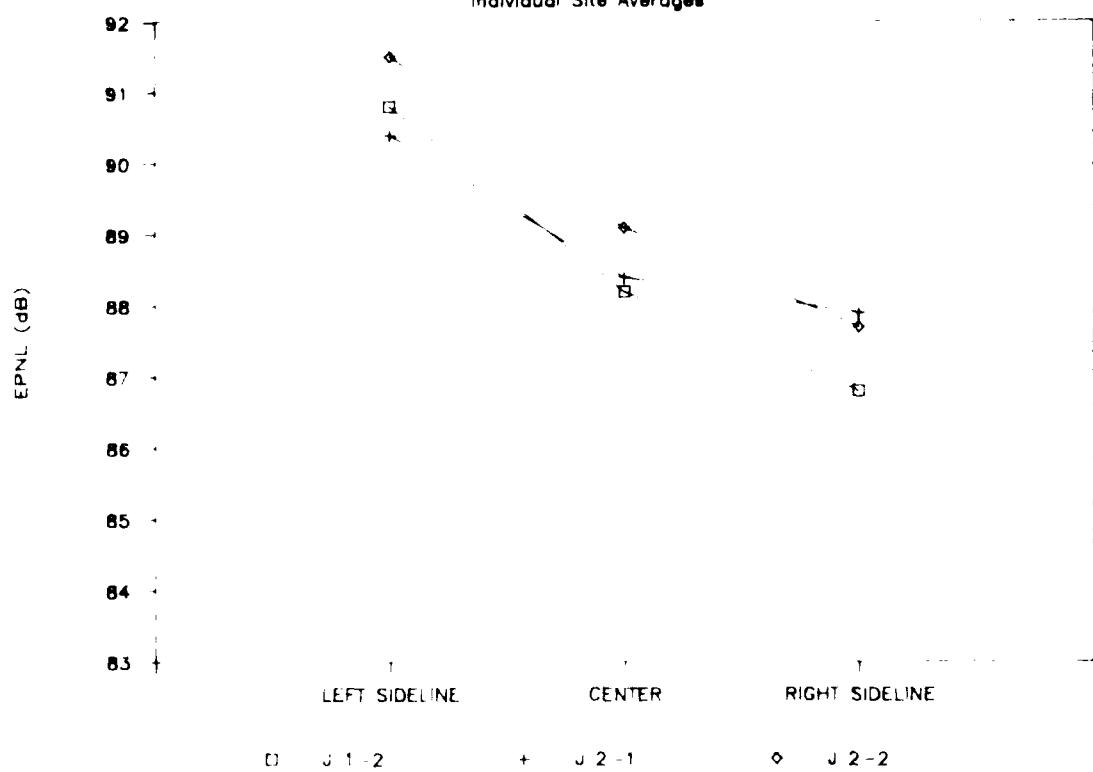
### EPNL-FLYOVER

Individual Site Averages



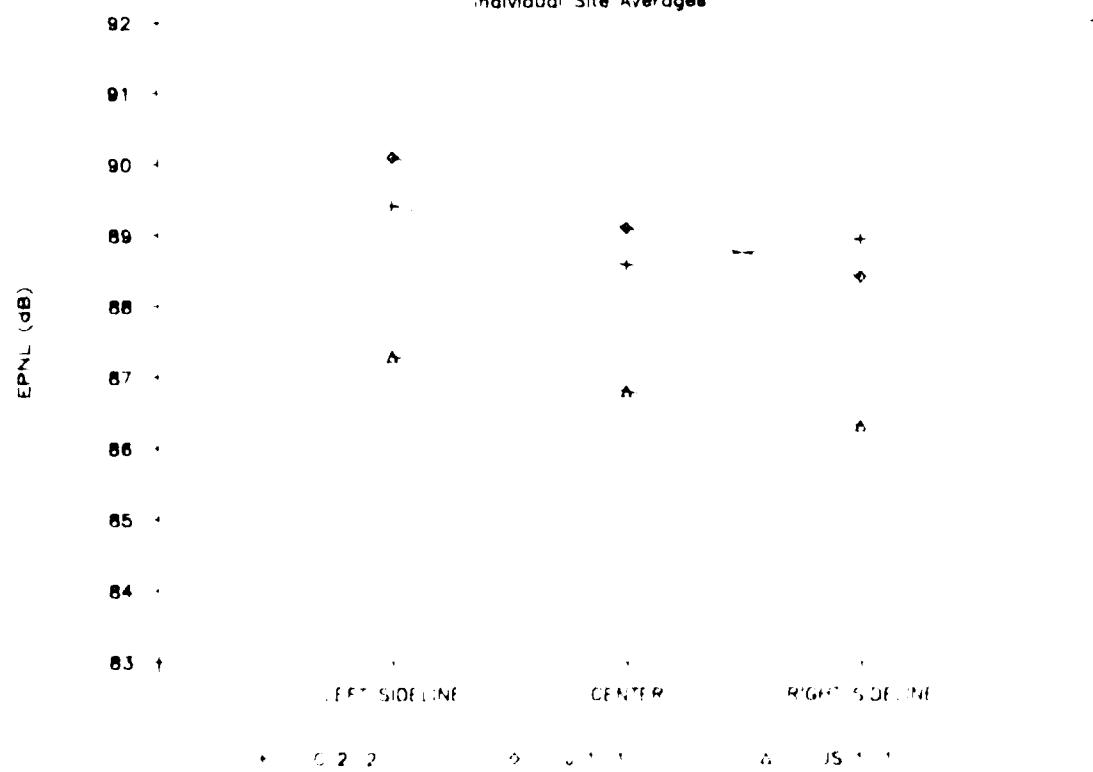
## EPNL-FLYOVER

Individual Site Averages



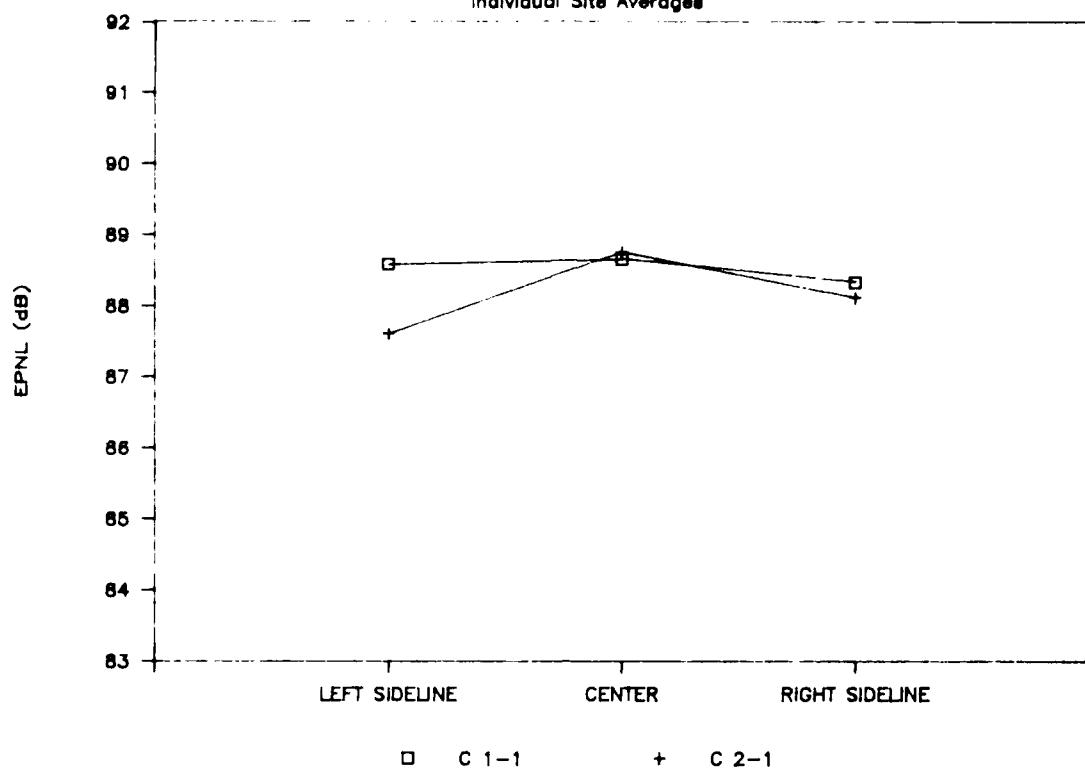
## EPNL-FLYOVER

Individual Site Averages



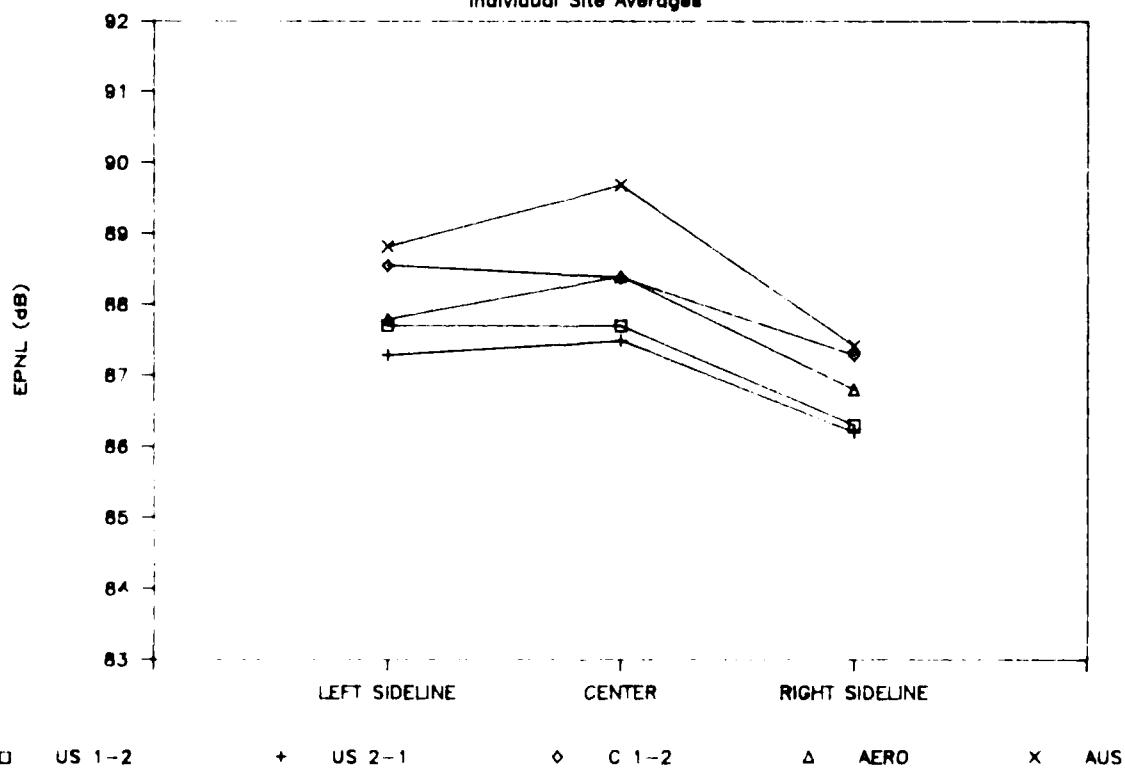
### EPNL - FLYOVER

Individual Site Averages



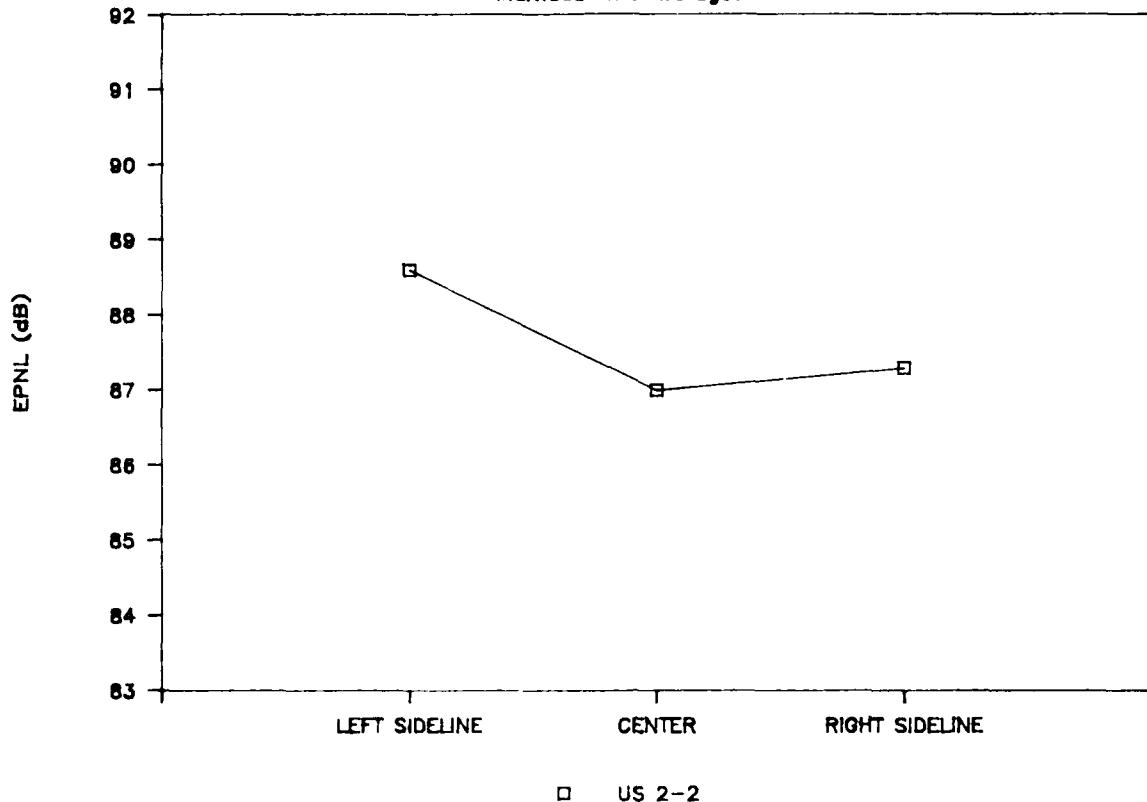
### EPNL - FLYOVER

Individual Site Averages



## EPNL-FLYOVER

Individual Site Averages

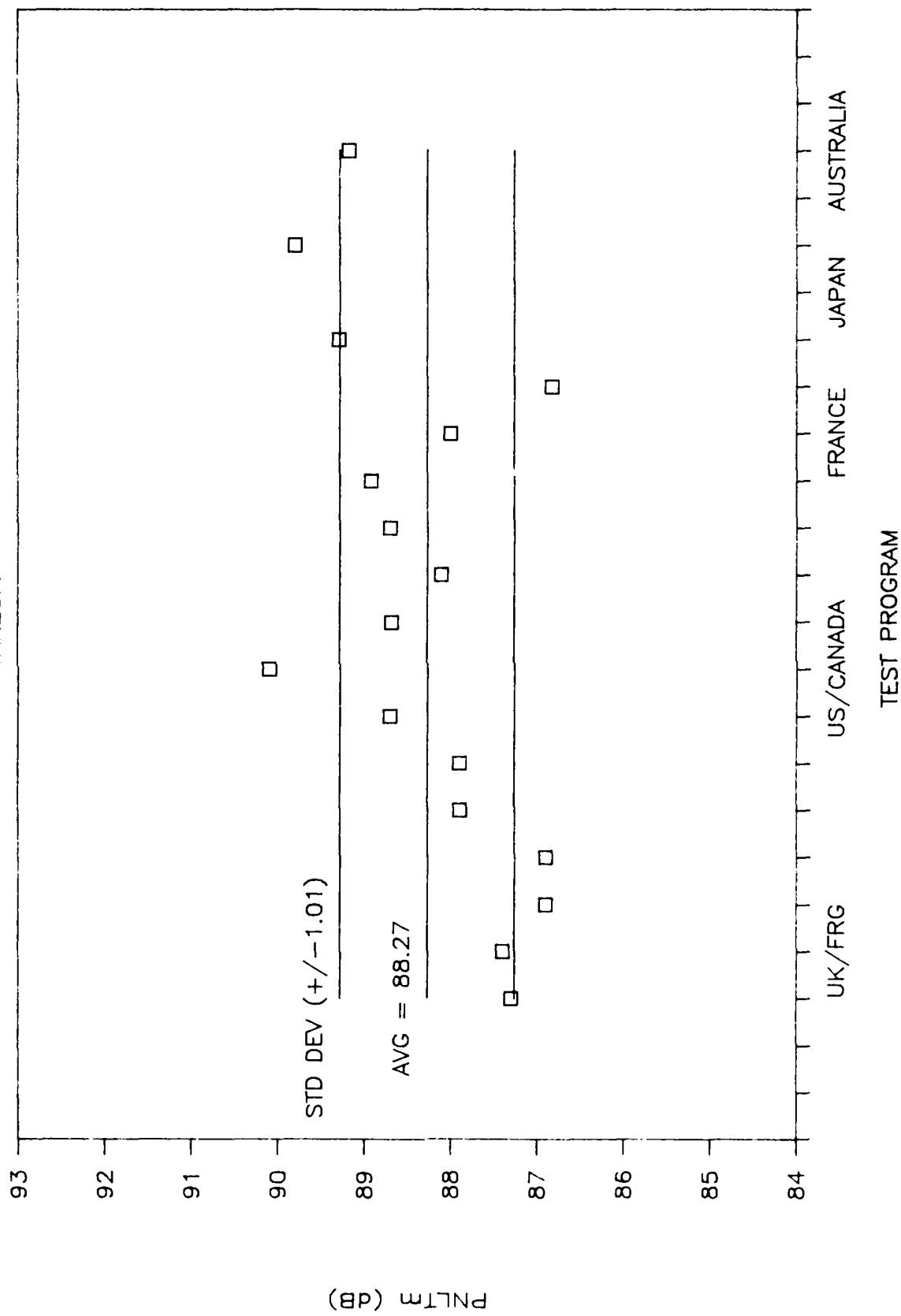


# **PNLTm Metric Multi-nation Comparison Data**

MULTI-NATION COMPARISON ANALYSIS  
TAKE-OFF PNLT™ DATA EXPRESSED IN DECIBELS (dB)

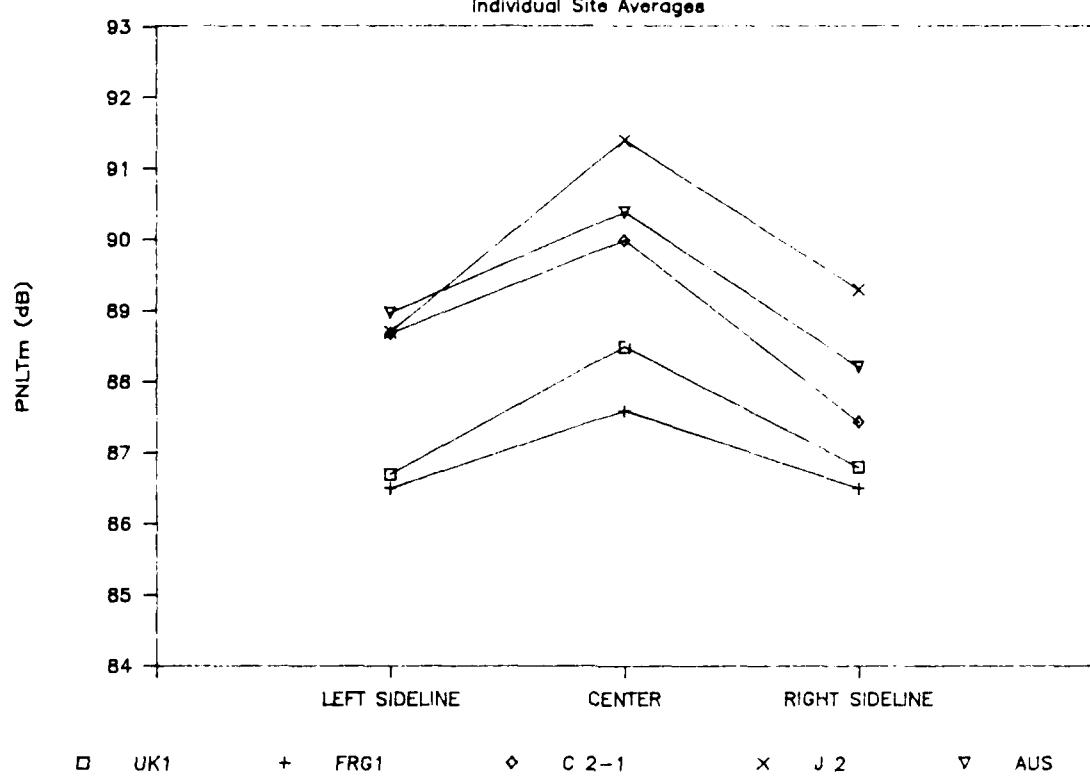
| PARTICIPANT      | LEFT     | CENTER | LINE     | RIGHT   | 3 MIC   |      |          | TEAM    | TEST    |       |
|------------------|----------|--------|----------|---------|---------|------|----------|---------|---------|-------|
|                  | SIDELINE | CENTER | SIDELINE | AVERAGE | AVERAGE | STD  | 90% C.I. | AVERAGE | AVERAGE |       |
| AUSTRALIA        | 88.97    | 90.39  | 88.21    |         | 89.18   | 0.48 | 0.21     |         | 89.18   | 89.18 |
| JAPAN-PILOT 1    | 89.30    | 89.70  | 88.90    |         | 89.29   | 0.32 | 0.20     |         | 89.55   | 89.55 |
| JAPAN-PILOT 2    | 88.70    | 91.40  | 89.30    |         | 89.80   | 0.56 | 0.35     |         |         |       |
| FRANCE-AERO      | 85.50    | 89.90  | 88.80    |         | 88.00   | 0.86 | 0.71     |         | 88.00   | 87.42 |
| FRANCE-STNA      | 85.30    | 89.30  | 85.90    |         | 86.83   | 0.50 | 0.40     |         | 86.83   |       |
| ITALY            | NA       | NA     | NA       |         | NA      | NA   | NA       |         |         |       |
| FRG-PILOT 1      | 86.50    | 87.60  | 86.50    |         | 86.90   | 0.30 | 0.30     |         | 86.90   | 87.13 |
| FRG-PILOT 2      | 87.40    | 86.90  | 86.40    |         | 86.90   | 0.20 | 0.10     |         |         |       |
| UK-PILOT 1       | 86.70    | 88.50  | 86.80    |         | 87.30   | 0.30 | 0.30     |         | 87.35   |       |
| UK-PILOT 2       | 87.30    | 87.70  | 87.20    |         | 87.40   | 0.30 | 0.30     |         |         |       |
| CANADA-PILOT 1-1 | 88.82    | 88.85  | 88.36    |         | 88.68   | 0.55 | 0.93     |         | 88.61   | 88.63 |
| CANADA-PILOT 1-2 | 89.41    | 88.58  | 86.34    |         | 88.11   | 0.02 | 0.07     |         |         |       |
| CANADA-PILOT 2-1 | 88.68    | 89.99  | 87.44    |         | 88.71   | 0.79 | 1.34     |         |         |       |
| CANADA-PILOT 2-2 | 86.85    | 90.82  | 89.08    |         | 88.92   | 1.37 | 2.31     |         |         |       |
| US-PILOT 1-1     | 87.80    | 88.30  | 87.50    |         | 87.90   | 0.55 | 0.37     |         | 88.65   |       |
| US-PILOT 1-2     | 88.70    | 87.70  | 87.20    |         | 87.90   | 0.18 | 0.17     |         |         |       |
| US-PILOT 2-1     | 88.70    | 89.10  | 88.20    |         | 88.70   | 0.49 | 0.36     |         |         |       |
| US-PILOT 2-2     | 90.20    | 90.70  | 89.30    |         | 90.10   | 0.86 | 0.71     |         |         |       |
| AVERAGE          | 87.93    | 89.14  | 87.73    |         | 88.27   | 0.51 | 0.54     |         | 88.13   | 88.38 |
| STD DEV          | 1.41     | 1.29   | 1.12     |         | 1.01    | 0.32 | 0.56     |         | 1.03    | 1.07  |
| 90% C.I.         | 0.88     | 0.81   | 0.70     |         | 0.63    | 0.20 | 0.35     |         | 1.09    | 1.79  |

PNLTm 3 MIC AVERAGE & STD DEVIATION  
TAKEOFF



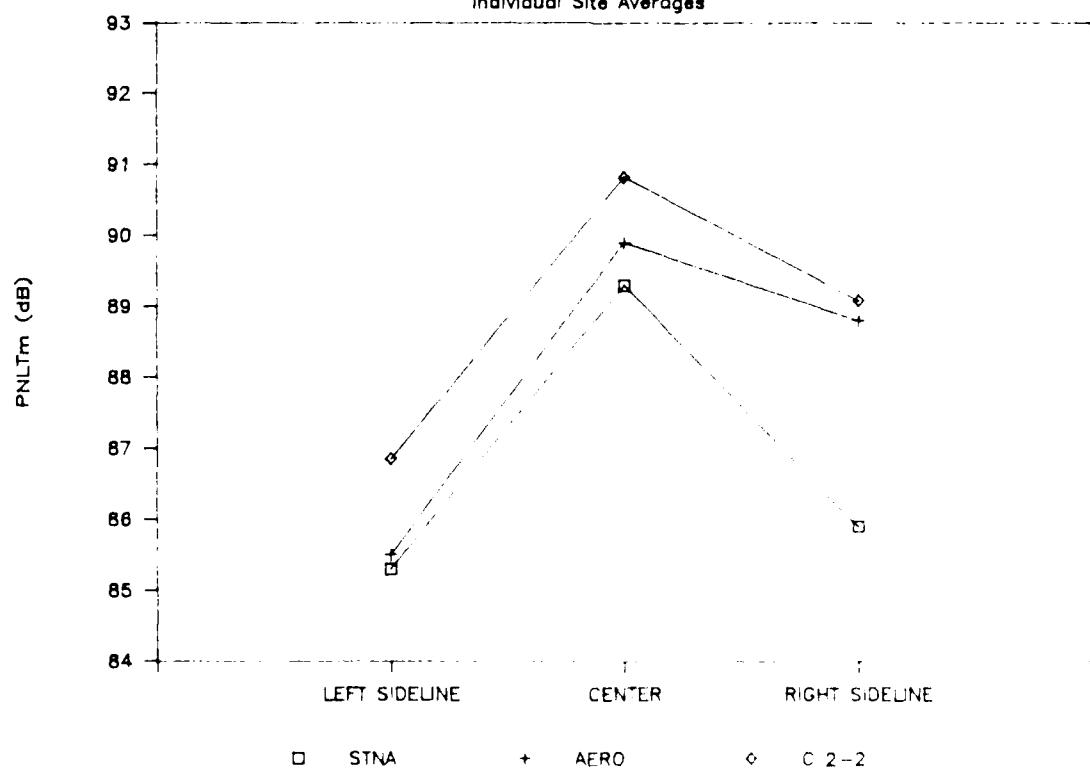
### PNLTm-TAKEOFF

Individual Site Averages



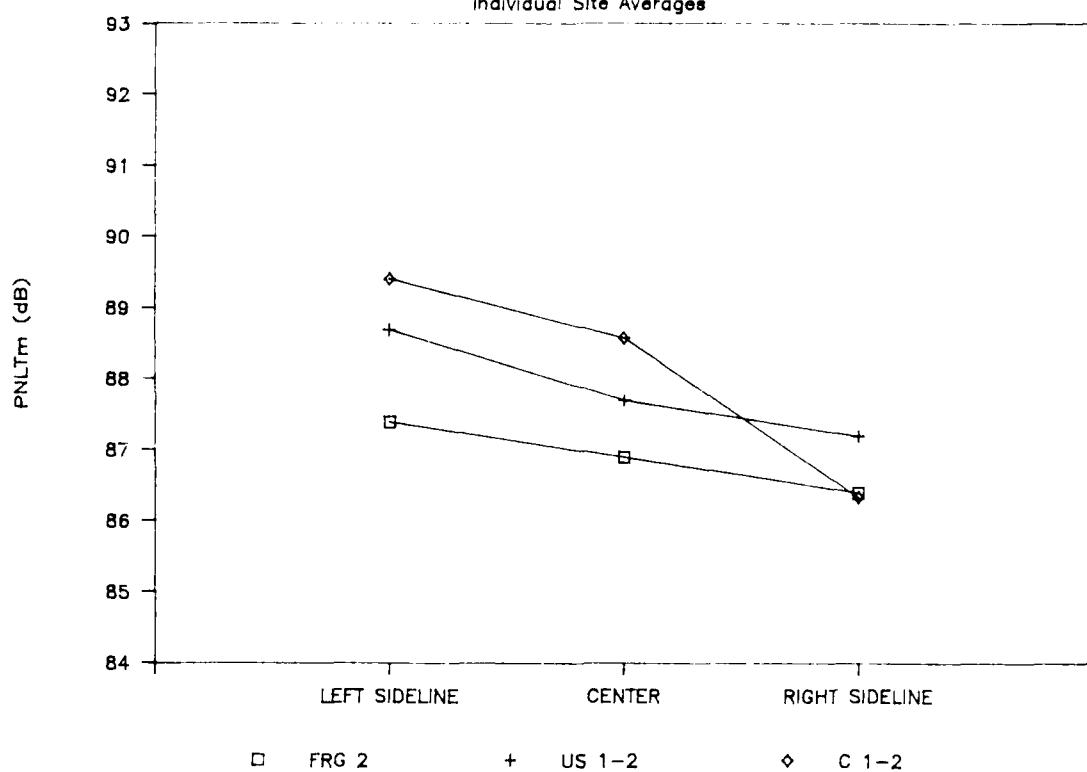
### PNLTm-TAKEOFF

Individual Site Averages



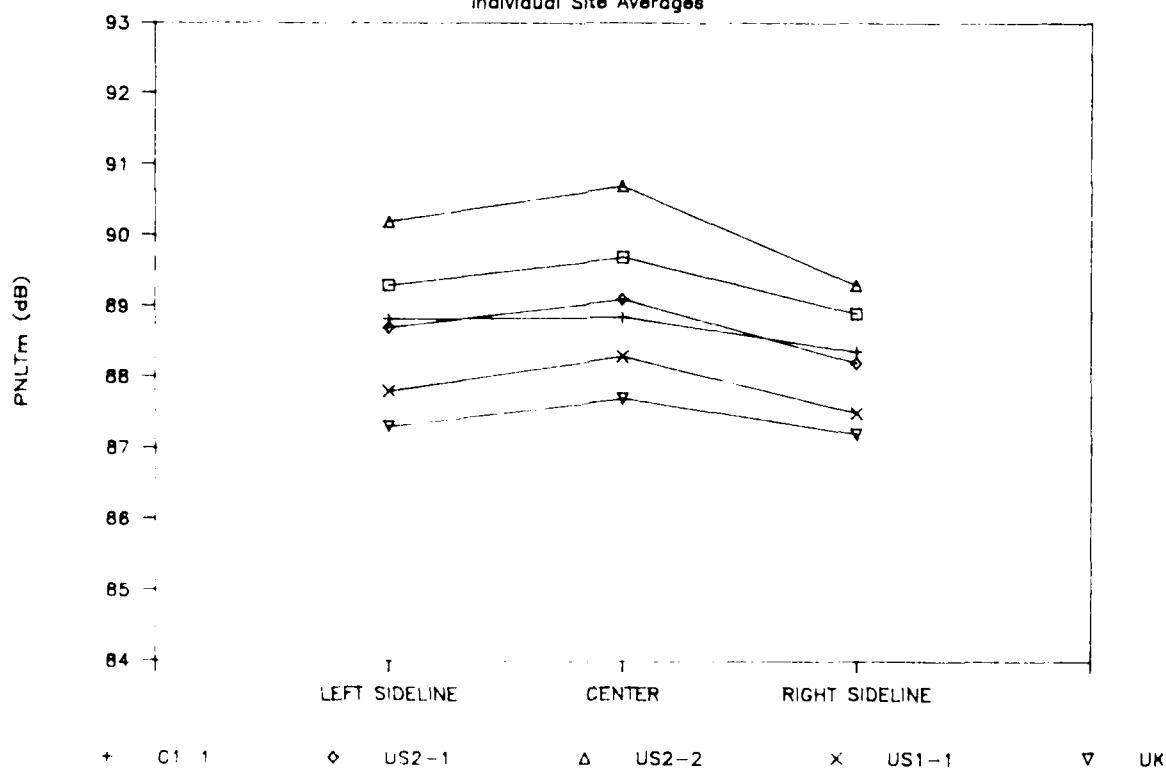
### PNLTm-TAKEOFF

*Individual Site Averages*



### PNLTm-TAKEOFF

*Individual Site Averages*

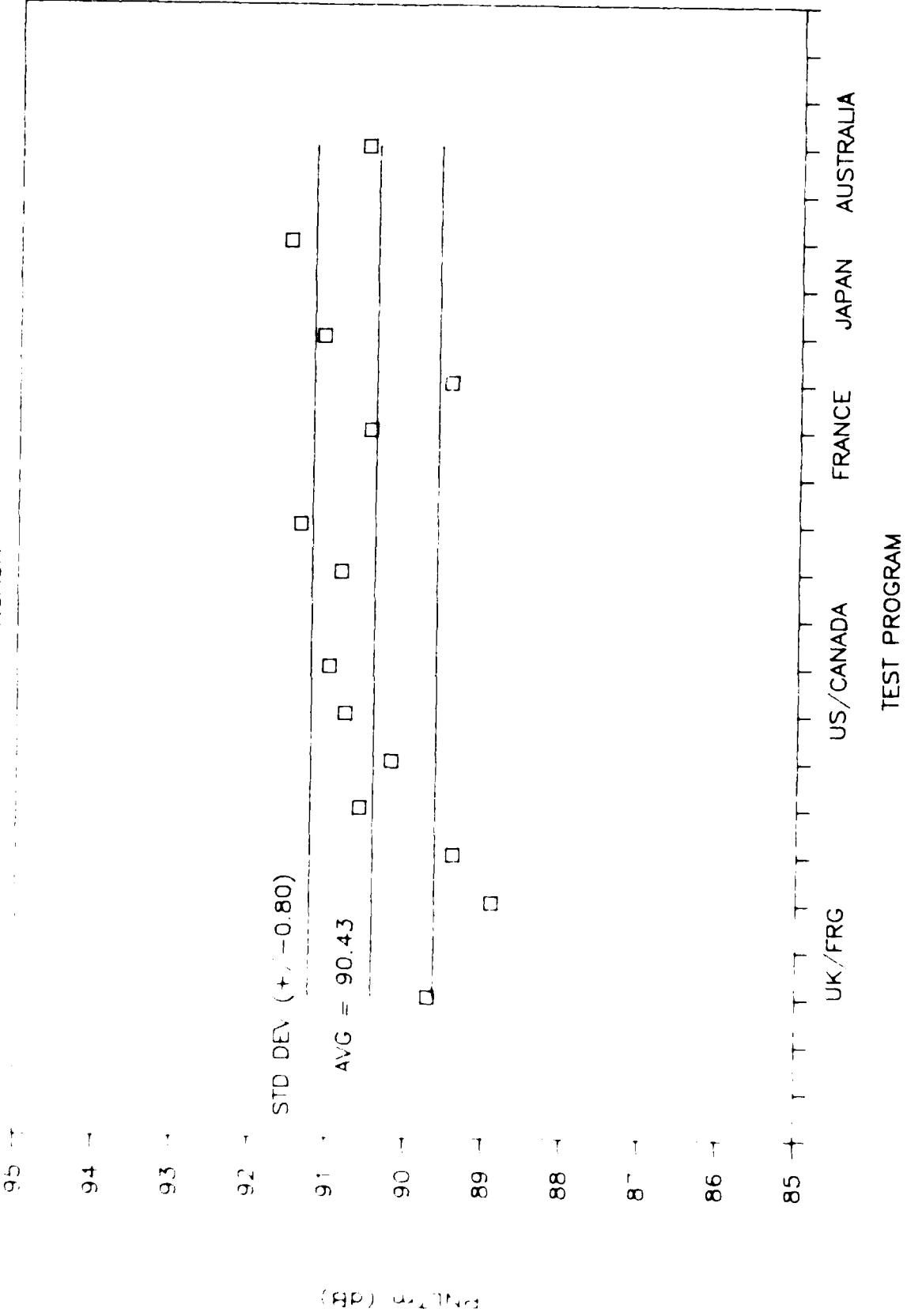


MULTI-NATION COMPARISON ANALYSIS  
APPROACH PNLT<sub>m</sub> DATA EXPRESSED IN DECIBELS (dB)

| PARTICIPANT      | LEFT                | CENTER LINE       | RIGHT               | 3 MIC<br>AVERAGE | STD<br>DEV | 90% C.I. | TEAM    | TEST    |
|------------------|---------------------|-------------------|---------------------|------------------|------------|----------|---------|---------|
|                  | SIDELINE<br>AVERAGE | CENTER<br>AVERAGE | SIDELINE<br>AVERAGE |                  |            |          | AVERAGE | AVERAGE |
| <hr/>            |                     |                   |                     |                  |            |          |         |         |
| AUSTRALIA        | 86.47               | 93.83             | 91.39               | 90.57            | 1.11       | 0.74     | 90.57   | 90.57   |
| JAPAN-PILOT 1    | 88.50               | 94.80             | 90.00               | 91.11            | 0.38       | 0.28     | 91.37   | 91.37   |
| JAPAN-PILOT 2    | 88.00               | 95.40             | 91.20               | 91.55            | 0.64       | 0.39     | 91.37   | 91.37   |
| FRANCE-AERO      | 86.60               | 94.70             | 90.10               | 90.50            | 1.22       | 2.06     | 91.47   | 90.47   |
| FRANCE-STNA      | 85.30               | 93.40             | 89.70               | 89.47            | 1.80       | 1.30     | 89.47   | 89.47   |
| ITALY            | NA                  | NA                | NA                  | NA               | NA         | NA       | NA      | NA      |
| FRG-PILOT 1      | 85.30               | 93.60             | 87.90               | 88.90            | 0.60       | 0.40     | 89.15   | 89.15   |
| FRG-PILOT 2      | 85.30               | 93.40             | 89.50               | 89.40            | 0.80       | 0.70     | 89.70   | 89.70   |
| UK-PILOT 1       | 85.60               | 93.80             | 89.60               | 89.70            | 0.80       | 0.70     | 89.70   | 89.70   |
| CANADA-PILOT 1-2 | 86.82               | 94.82             | 90.93               | 90.86            | 0.32       | 1.44     | 91.13   | 90.81   |
| CANADA-PILOT 2-1 | 86.78               | 95.85             | 91.54               | 91.39            | 0.26       | 0.43     | 90.55   | 90.55   |
| US-PILOT 1-1     | 86.90               | 94.10             | 90.90               | 90.60            | 0.87       | 0.58     | 90.55   | 90.55   |
| US-PILOT 1-2     | 86.30               | 94.00             | 90.20               | 90.20            | 0.38       | 0.36     | 90.70   | 90.70   |
| US-PILOT 2-1     | 86.30               | 94.50             | 91.10               | 90.80            | 0.58       | 0.42     | 90.70   | 90.70   |
| US-PILOT 2-2     | 86.70               | 94.20             | 92.00               | 91.00            | 0.43       | 0.26     | 90.70   | 90.70   |
| <hr/>            |                     |                   |                     |                  |            |          |         |         |
| AVERAGE          | 86.49               | 94.31             | 90.43               | 90.43            | 0.73       | 0.72     | 90.43   | 90.50   |
| STD DEV          | 0.95                | 0.74              | 1.07                | 0.80             | 0.42       | 0.53     | 0.89    | 0.77    |
| 90% C.I.         | 0.68                | 0.52              | 0.76                | 0.56             | 0.30       | 0.37     | 0.94    | 0.70    |

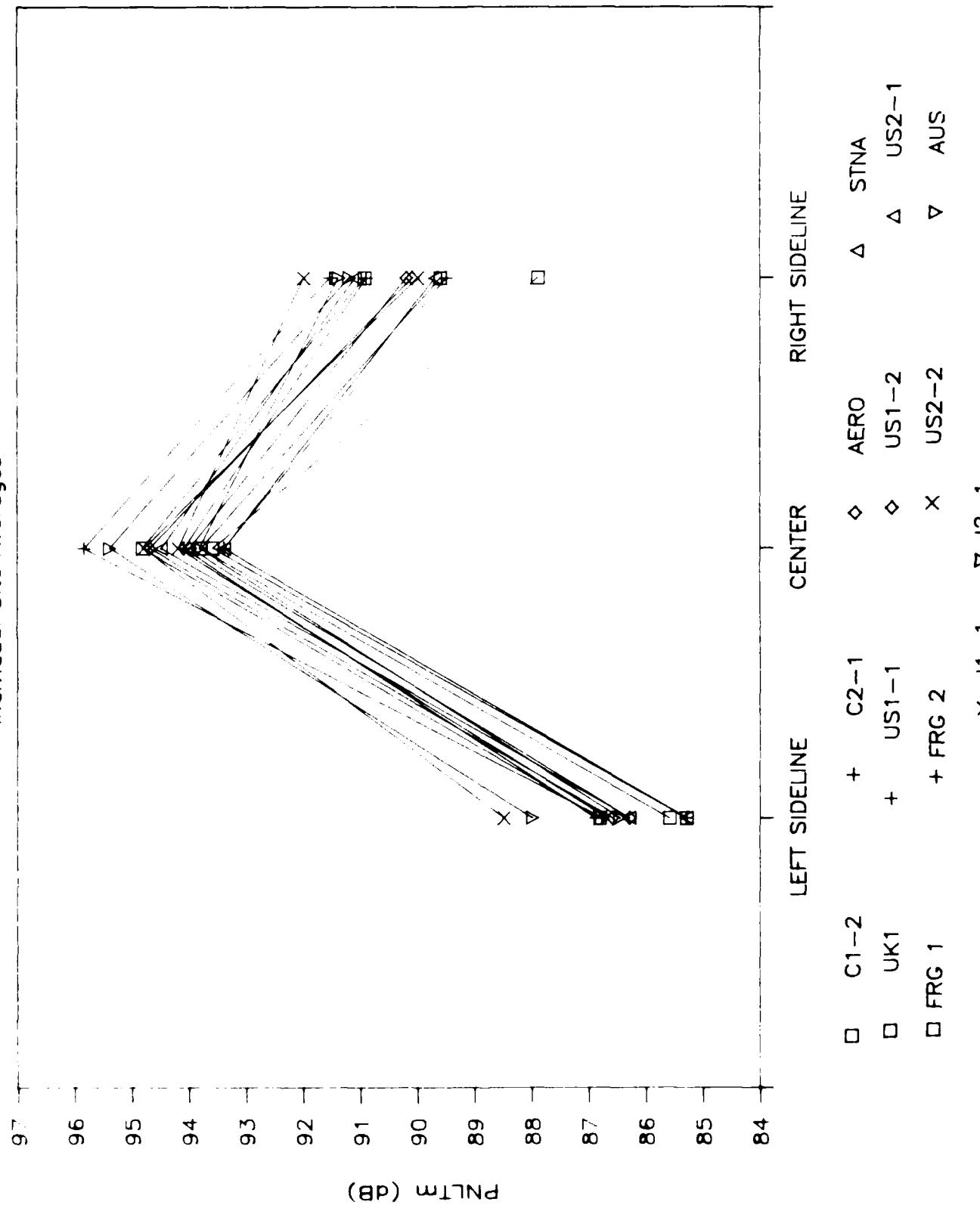
# DNLTm 3 MIC AVERAGE & STD DEVIATION

## APPROACH



# PNLTM-APPROACH

## Individual Site Averages



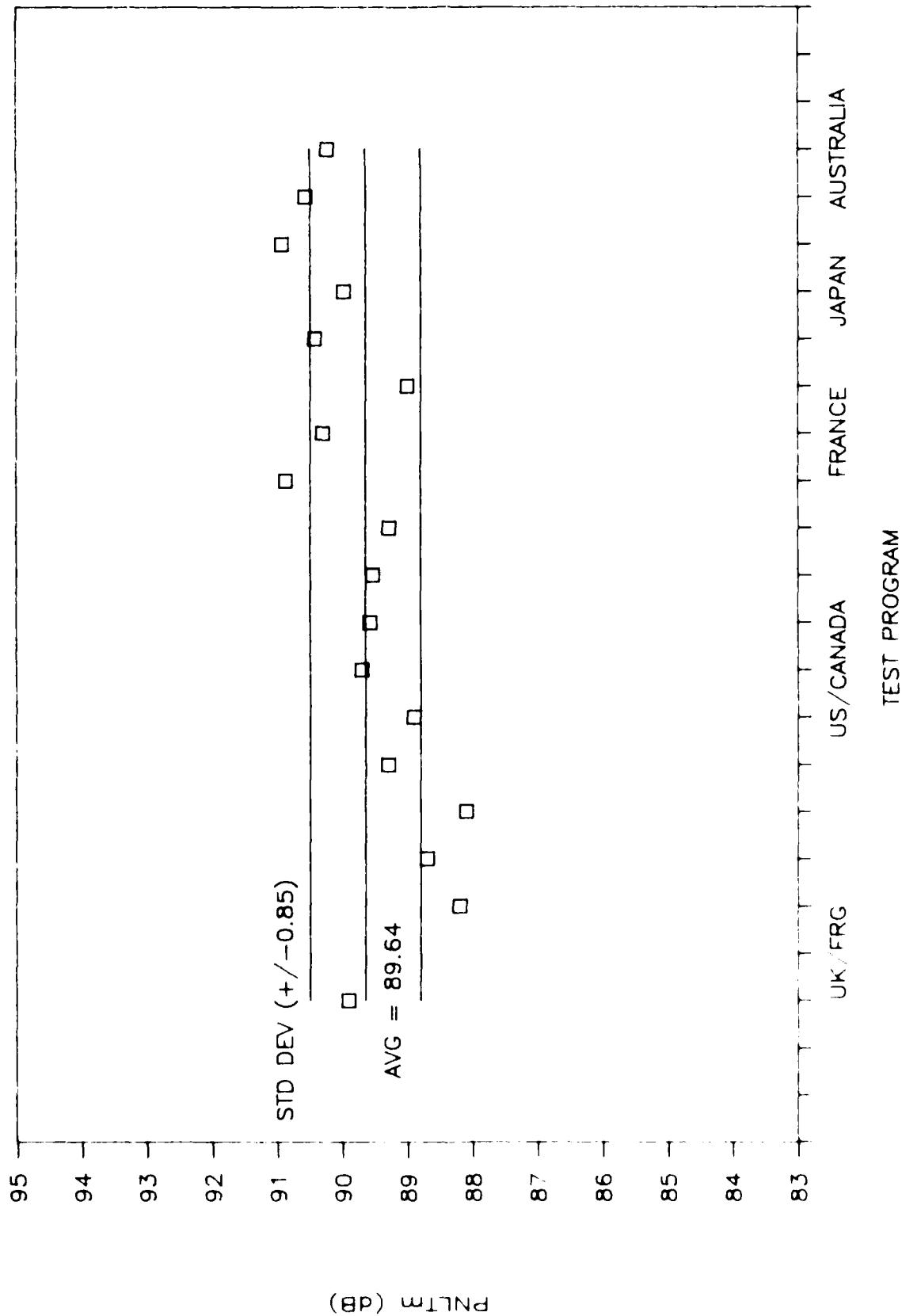
MULTI-NATION COMPARISON ANALYSIS  
LEVEL FLYOVER PNLT<sup>a</sup> DATA EXPRESSED IN DECIBELS (dB)

| PARTICIPANT      | LEFT                | CENTER            | LINE                | RIGHT | 3 MIC<br>AVERAGE | STD<br>DEV | 90% C.I. | TEAM<br>AVERAGE | TEST<br>AVERAGE |
|------------------|---------------------|-------------------|---------------------|-------|------------------|------------|----------|-----------------|-----------------|
|                  | SIDELINE<br>AVERAGE | CENTER<br>AVERAGE | SIDELINE<br>AVERAGE |       |                  |            |          |                 |                 |
| AUSTRALIA        | 90.16               | 92.22             | 88.30               |       | 90.23            | 0.61       | 0.33     | 90.23           | 90.23           |
| JAPAN-PILOT 1-1  | 91.04               | 91.44             | 88.79               |       | 90.42            | 0.14       | 0.18     | 90.48           | 90.48           |
| JAPAN-PILOT 1-2  | 91.33               | 90.99             | 87.63               |       | 89.98            | 0.31       | 0.52     | 89.98           | 89.98           |
| JAPAN-PILOT 2-1  | 91.93               | 91.87             | 89.01               |       | 90.93            | 0.38       | 0.44     | 90.93           | 90.93           |
| JAPAN-PILOT 2-2  | 91.87               | 91.56             | 88.35               |       | 90.57            | 0.16       | 0.19     | 90.57           | 90.57           |
| FRANCE-AERO      | 90.79               | 91.20             | 89.00               |       | 90.30            | 0.64       | 0.75     | 90.30           | 90.65           |
| FRANCE-STNA      | 89.30               | 91.00             | 86.80               |       | 89.00            | 0.60       | 0.80     | 89.00           | 89.00           |
| ITALY            | NA                  | NA                | NA                  |       | NA               | NA         | NA       | NA              | NA              |
| FRG-PILOT 1      | 88.00               | 90.50             | 86.10               |       | 88.20            | 0.20       | 0.20     | 88.45           | 88.97           |
| FRG-PILOT 2      | 87.80               | 91.60             | 86.70               |       | 88.70            | 0.30       | 0.30     | 88.70           | 88.70           |
| UK-PILOT 1       | 90.40               | 92.20             | 86.90               |       | 89.90            | NA         | NA       | 89.90           | 89.90           |
| CANADA-PILOT 1-1 | 88.88               | 90.38             | 89.44               |       | 89.57            | 0.27       | 0.26     | 89.81           | 89.41           |
| CANADA-PILOT 1-2 | 89.76               | 91.27             | 87.56               |       | 89.53            | 0.80       | 0.71     | 89.53           | 89.53           |
| CANADA-PILOT 2-1 | 88.17               | 91.41             | 88.25               |       | 89.28            | 0.47       | 1.09     | 89.28           | 89.28           |
| CANADA-PILOT 2-2 | 91.49               | 91.46             | 89.68               |       | 90.87            | 0.80       | 0.94     | 90.87           | 90.87           |
| US-PILOT 1-1     | 88.00               | 89.10             | 87.30               |       | 88.10            | 0.27       | 0.20     | 89.00           | 89.00           |
| US-PILOT 1-2     | 89.70               | 90.60             | 87.60               |       | 89.30            | 0.14       | 0.18     | 89.30           | 89.30           |
| US-PILOT 2-1     | 89.00               | 89.90             | 87.80               |       | 86.90            | 0.23       | 0.19     | 86.90           | 86.90           |
| US-PILOT 2-2     | 90.50               | 89.70             | 88.80               |       | 89.70            | 0.46       | 0.28     | 89.70           | 89.70           |
| AVERAGE          | 89.89               | 91.02             | 88.00               |       | 89.64            | 0.39       | 0.50     | 89.65           | 89.74           |
| STD DEV          | 1.33                | 0.85              | 1.91                |       | 0.85             | 0.30       | 0.48     | 0.74            | 0.82            |
| 90% C.I.         | 0.83                | 0.51              | 0.61                |       | 0.51             | 0.13       | 0.20     | 0.78            | 1.04            |

UK delta 3 calculated at 15<sup>o</sup>C

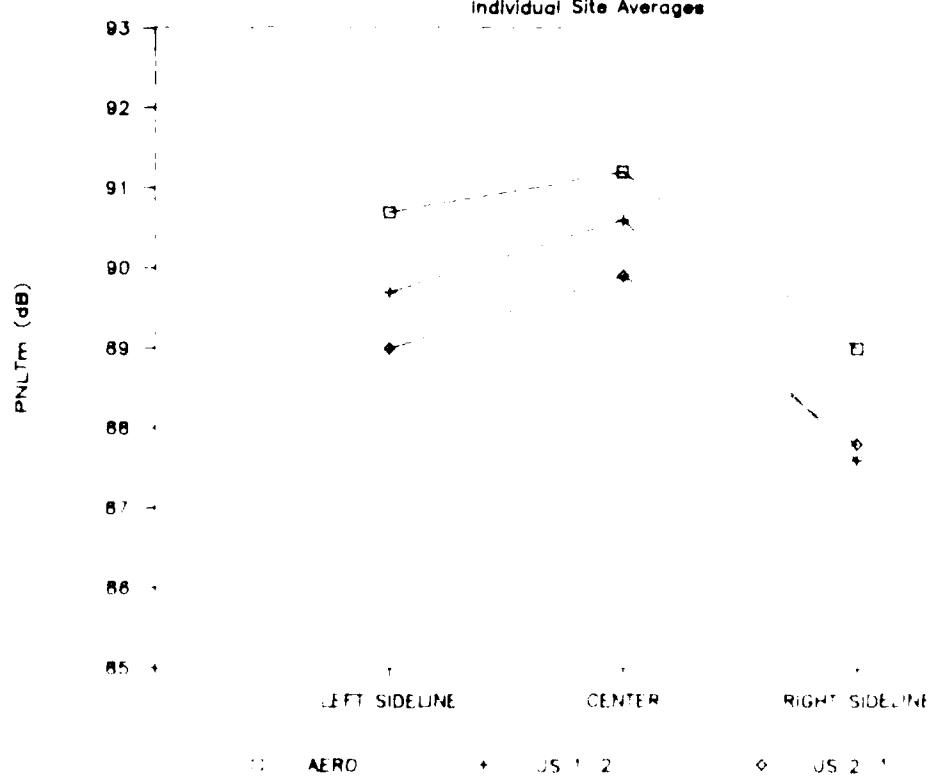
## PNLTm 3 MIC AVERAGE & STD DEVIATION

UK delta 3 calculated at 15° C



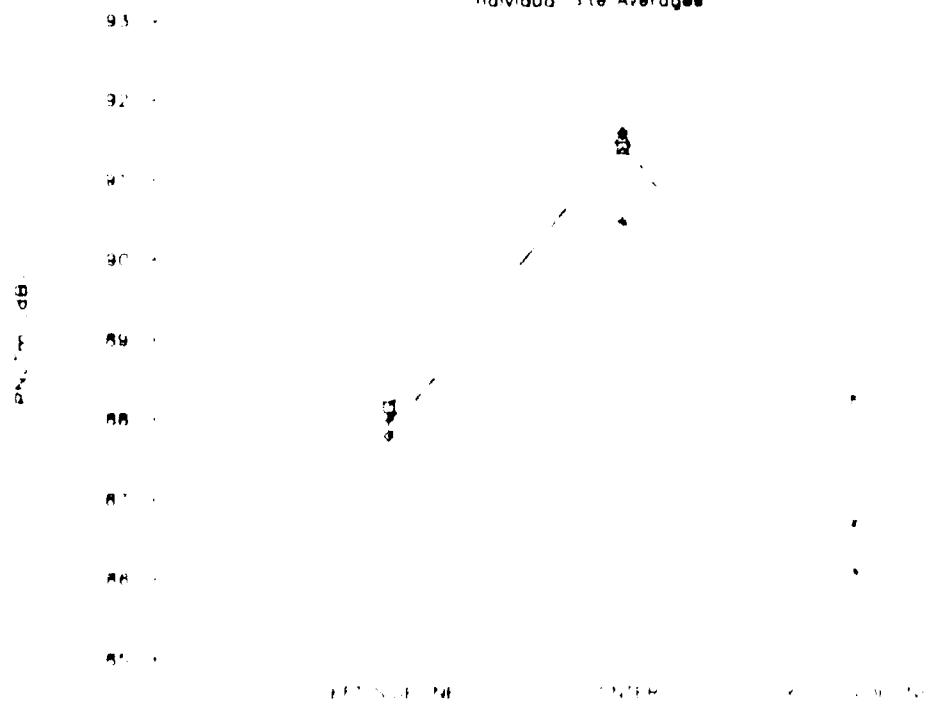
## PNLTm-LEVEL FLYOVER

Individual Site Averages



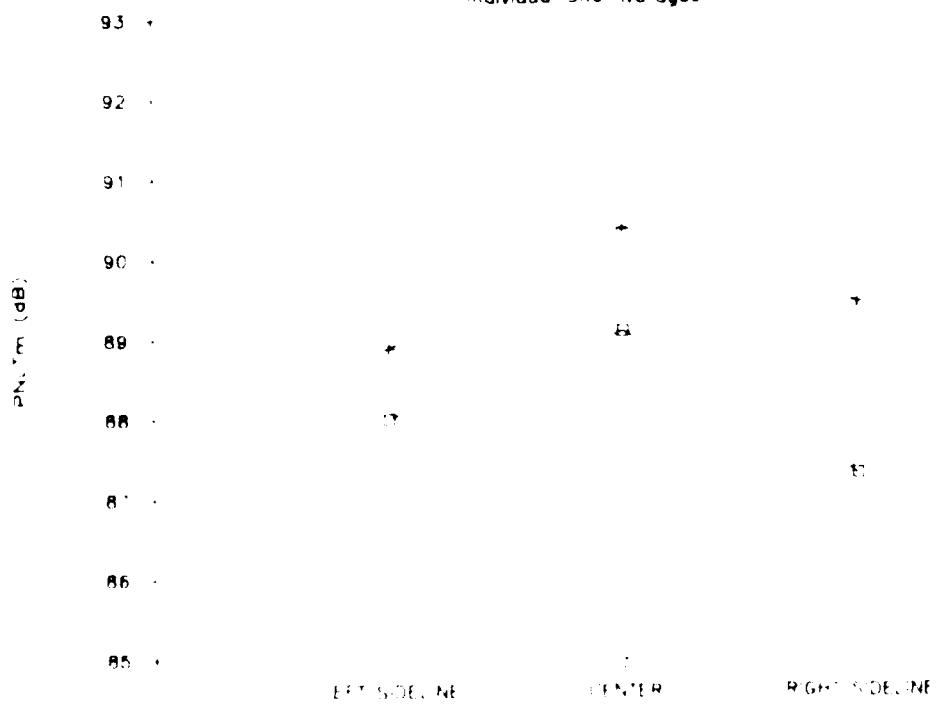
## PNTtm-LEVEL FLYOVER

Individual Site Averages

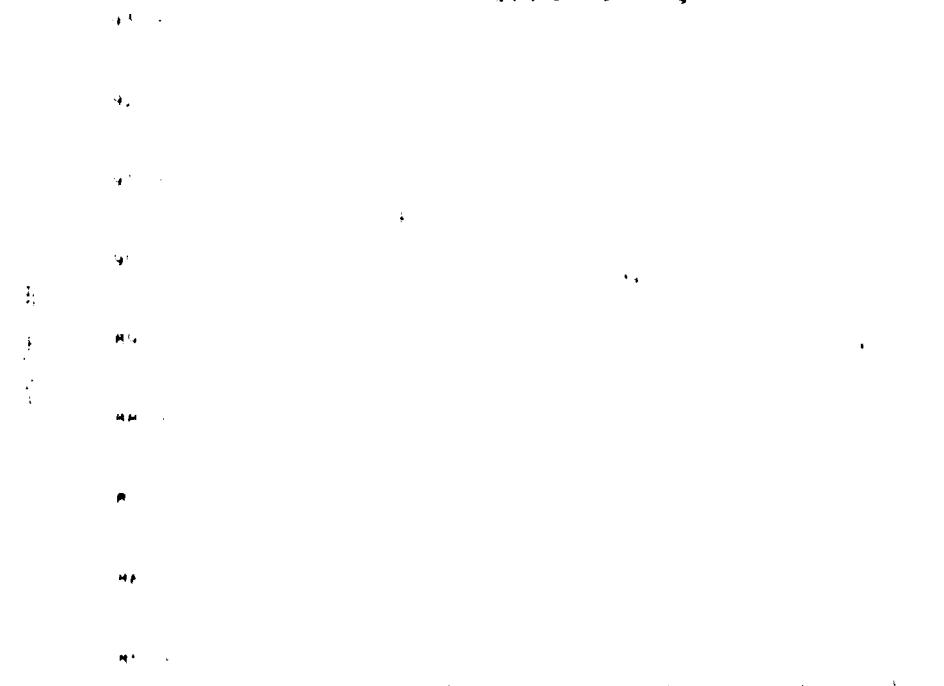


## POLYLINE-LEVEL FLY-OVER

Individual Site Averages

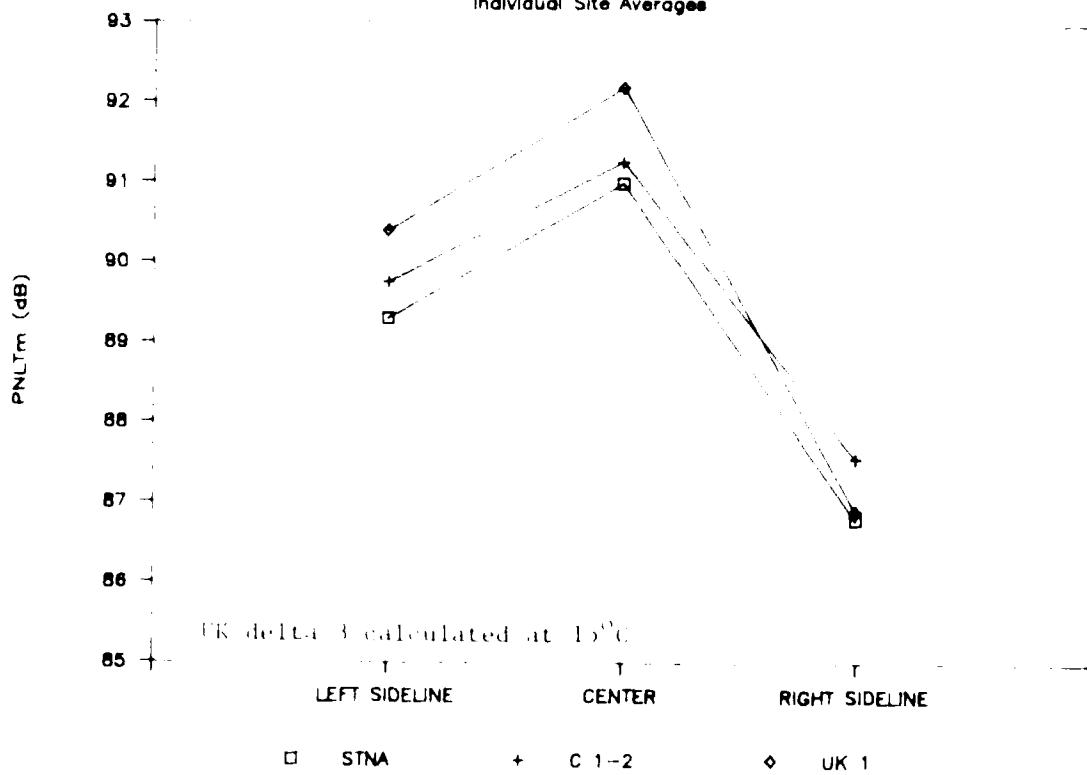


Individual Site Averages



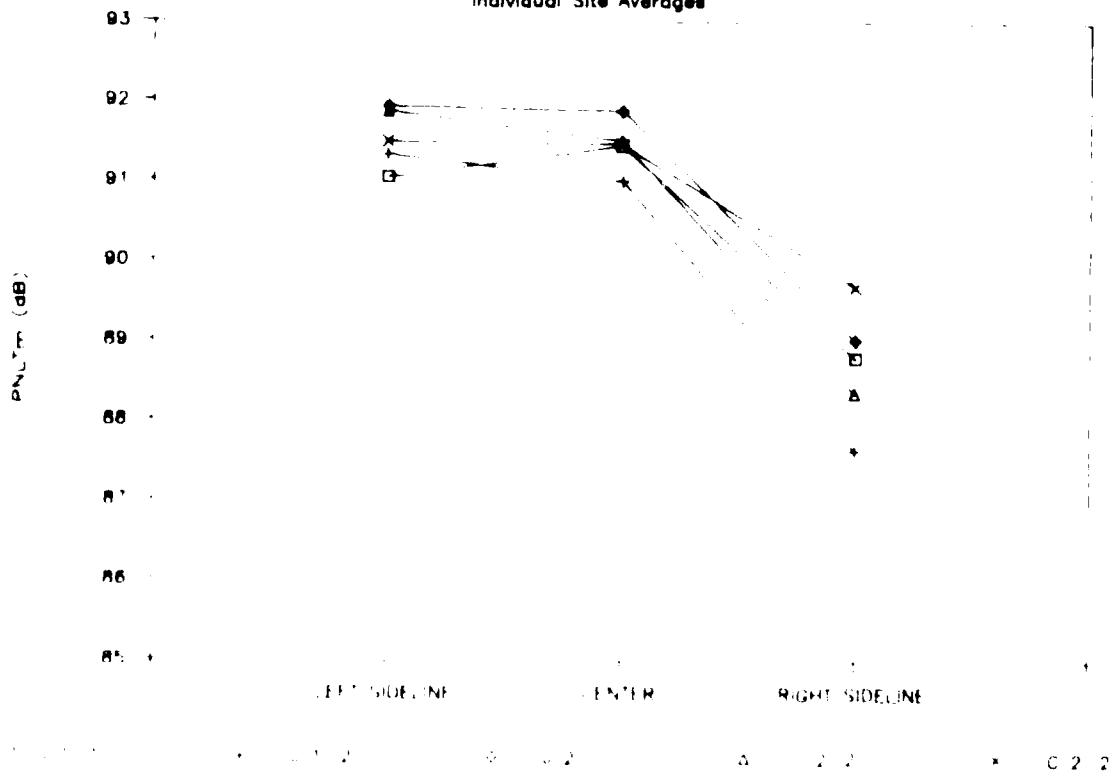
### PNLTm-LEVEL FLYOVER

Individual Site Averages



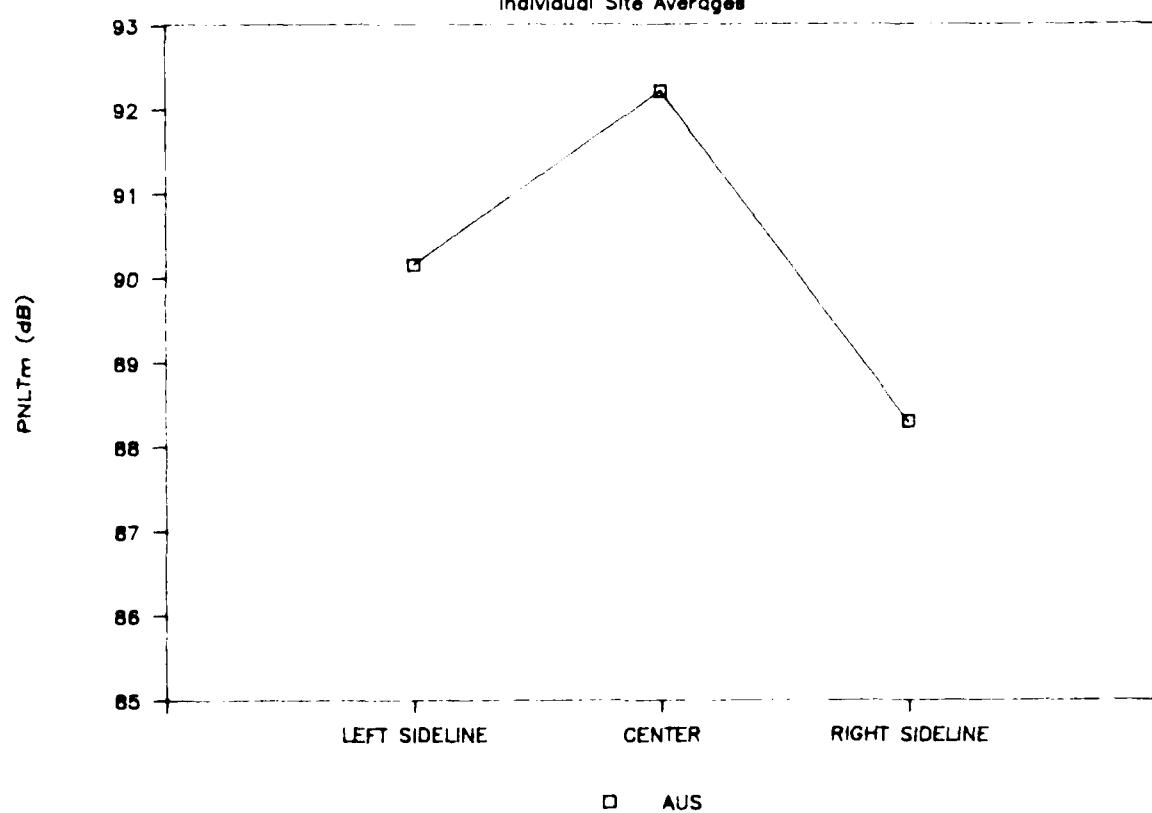
### PNLTm-LEVEL FLYOVER

Individual Site Averages



## PNLTm-LEVEL FLYOVER

Individual Site Averages

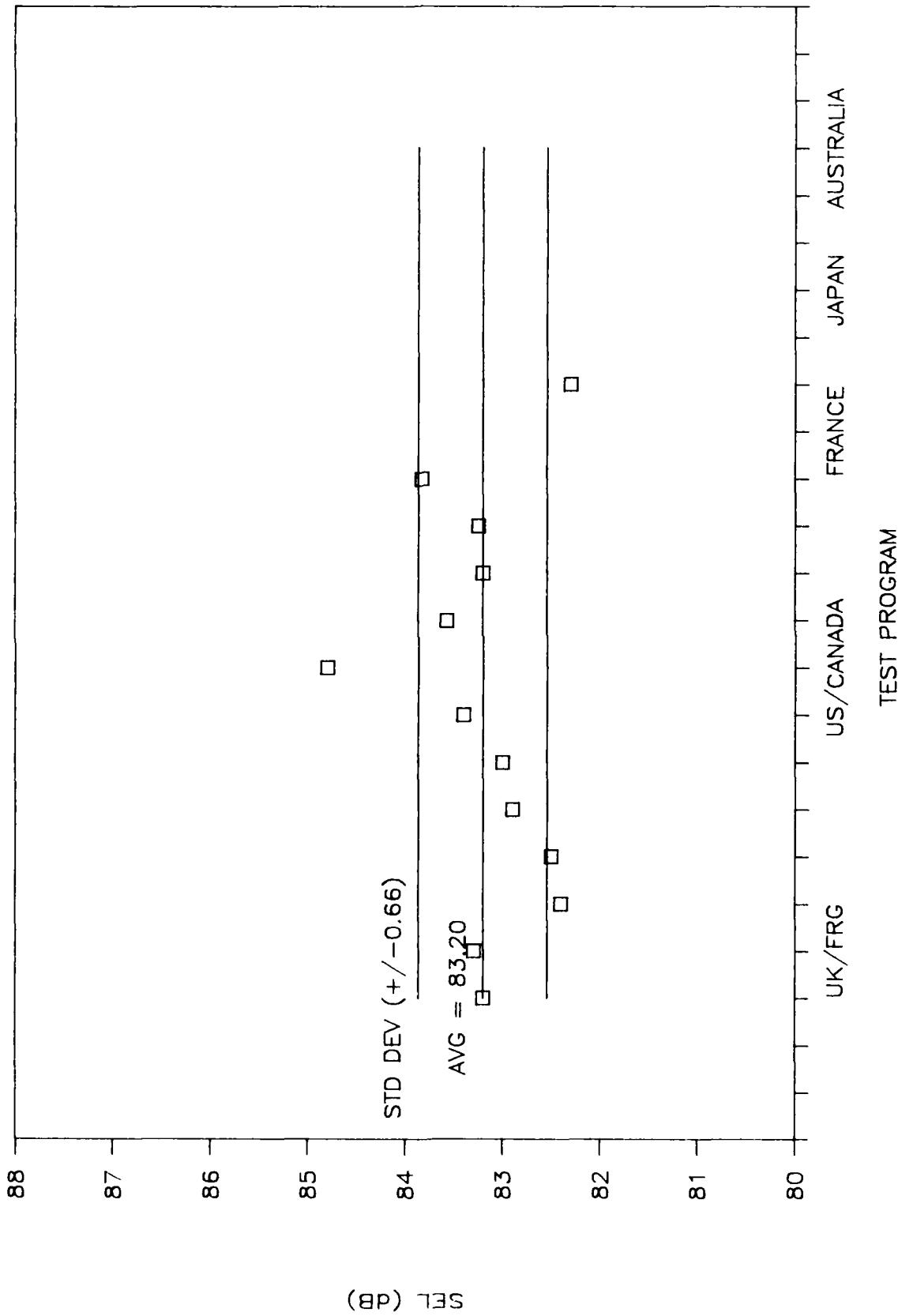


# **SEL Metric Multi-nation Comparison Data**

MULTI-NATION COMPARISON ANALYSIS  
TAKE-OFF SEL DATA EXPRESSED IN DEGREES (dB)

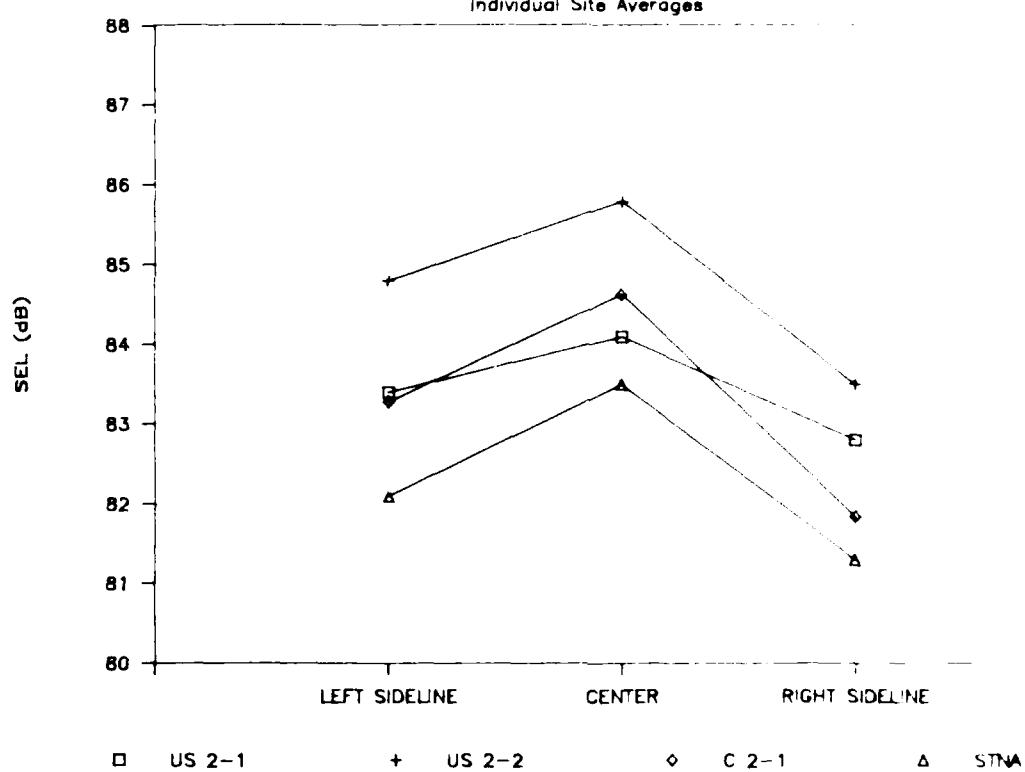
| PARTICIPANT      | LEFT     |        | CENTER LINE |        | RIGHT    |        | TERM  | TEST  |
|------------------|----------|--------|-------------|--------|----------|--------|-------|-------|
|                  | SIDELINE | CENTER | SIDELINE    | CENTER | SIDELINE | CENTER |       |       |
| AUSTRALIA        | NH       | NH     | NH          | NH     | NH       | NH     | NH    | NH    |
| GERMANY-PILOT 1  | NH       | NH     | NH          | NH     | NH       | NH     | NH    | NH    |
| GERMANY-PILOT 2  | NH       | NH     | NH          | NH     | NH       | NH     | NH    | NH    |
| FRANCE-AERO      | NH       | NH     | NH          | NH     | NH       | NH     | NH    | NH    |
| FRANCE-SPHER     | 81.14    | 81.54  | 81.04       | 81.74  | 81.74    | 81.24  | 81.24 | 81.74 |
| ITALY            | NH       | NH     | NH          | NH     | NH       | NH     | NH    | NH    |
| FRG-PILOT 1      | 81.84    | 81.84  | 81.74       | 81.44  | 81.34    | 81.34  | 81.44 | 81.64 |
| FRG-PILOT 2      | 81.74    | 81.14  | 81.64       | 81.54  | 81.24    | 81.24  | 81.24 | 81.24 |
| UK-PILOT 1       | 81.54    | 81.74  | 81.54       | 81.24  | 81.74    | 81.54  | 81.54 | 81.24 |
| UK-PILOT 2       | 81.54    | 81.14  | 81.14       | 81.74  | 81.34    | 81.24  | 81.24 | 81.24 |
| CANADA-PILOT 1-1 | 81.74    | 81.54  | 81.44       | 81.54  | 81.74    | 81.54  | 81.44 | 81.44 |
| CANADA-PILOT 1-2 | 84.24    | 81.54  | 81.84       | 81.24  | 81.24    | 81.14  | 81.14 | 81.14 |
| CANADA-PILOT 1-3 | 81.24    | 84.64  | 81.84       | 81.24  | 81.24    | 81.24  | 81.24 | 81.24 |
| CANADA-PILOT 2-1 | 81.74    | 85.54  | 81.44       | 81.84  | 81.84    | 81.84  | 81.84 | 81.84 |
| US-PILOT 1-1     | 81.44    | 81.84  | 81.84       | 81.44  | 81.44    | 81.24  | 81.14 | 81.54 |
| US-PILOT 1-2     | 81.54    | 81.54  | 81.44       | 81.24  | 81.24    | 81.24  | 81.24 | 81.24 |
| US-PILOT 1-3     | 81.44    | 84.14  | 81.84       | 81.44  | 81.44    | 81.54  | 81.44 | 81.44 |
| US-PILOT 2-1     | 84.84    | 85.84  | 81.54       | 84.84  | 84.84    | 81.54  | 81.44 | 81.44 |
| AVERAGE          | 81.14    | 81.74  | 81.74       | 81.24  | 81.44    | 81.54  | 81.24 | 81.74 |
| STD DE.          | .86      | 1.14   | 1.81        | 1.86   | 1.15     | 1.45   | 1.58  | 1.46  |
| STD C.V.         | 1.54     | 1.81   | 1.81        | 1.44   | 1.16     | 1.37   | 1.47  | 1.18  |

SEL 3 MIC AVERAGE & STD DEVIATION  
TAKEOFF



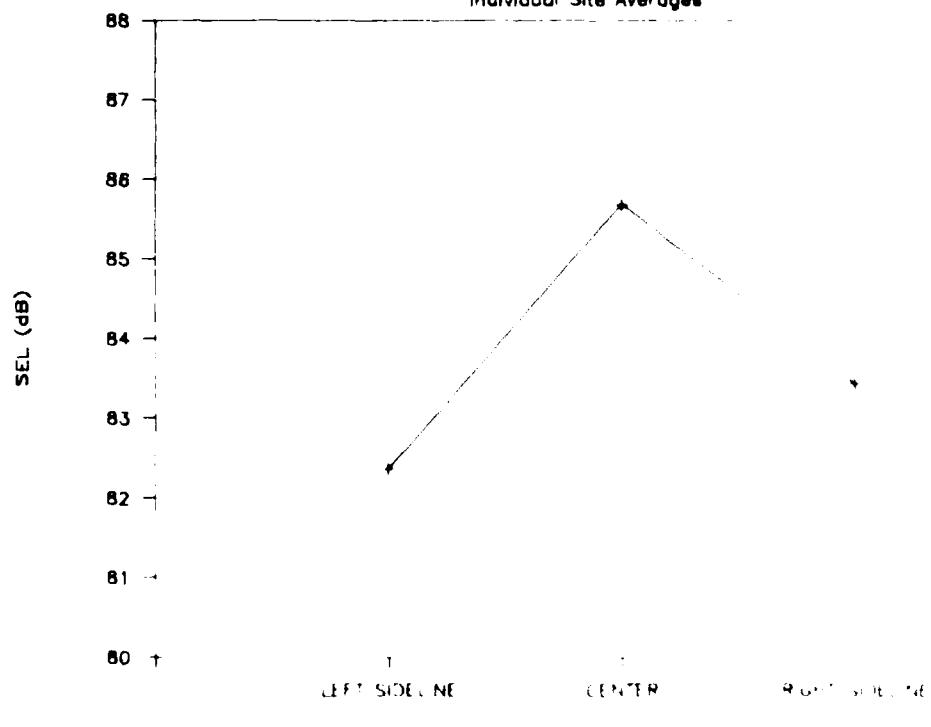
### SEL-TAKEOFF

Individual Site Averages



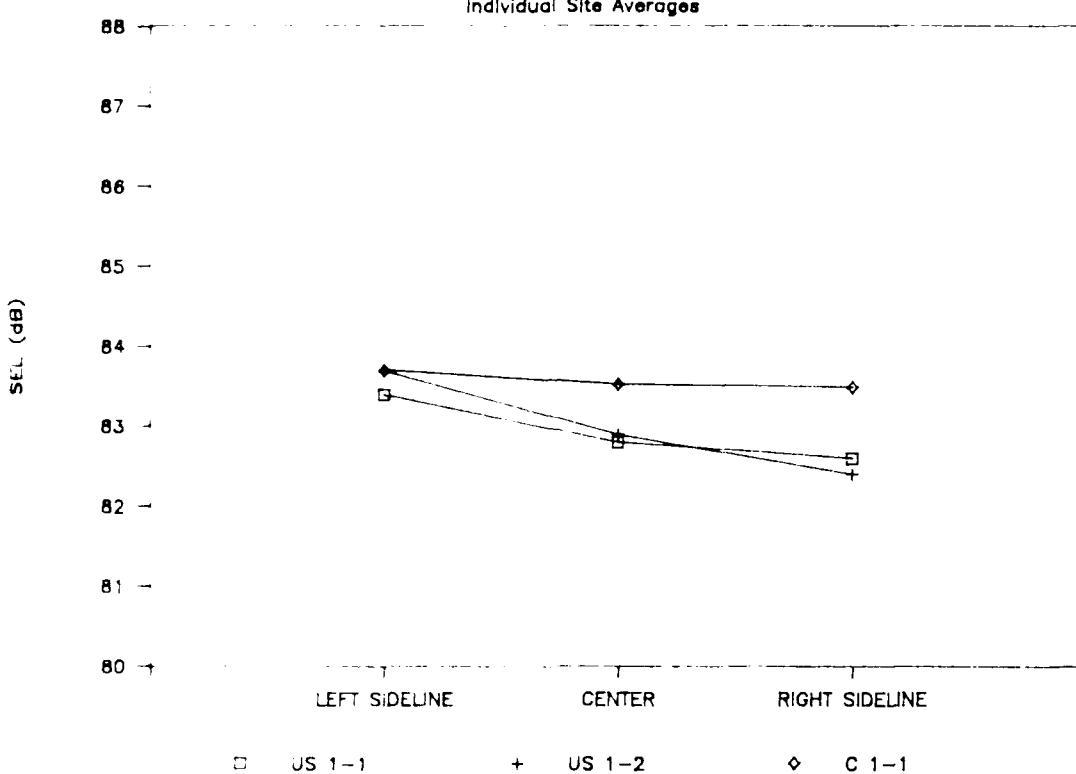
### SEL-TAKEOFF

Individual Site Averages



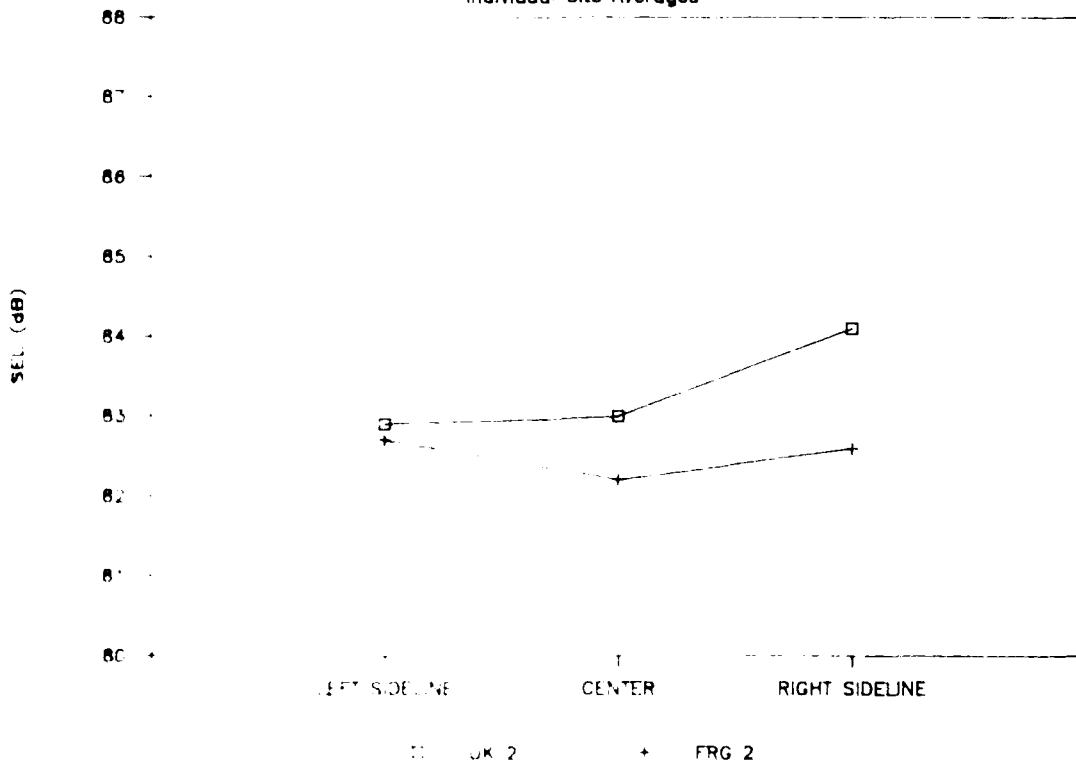
## SEL-TAKEOFF

Individual Site Averages



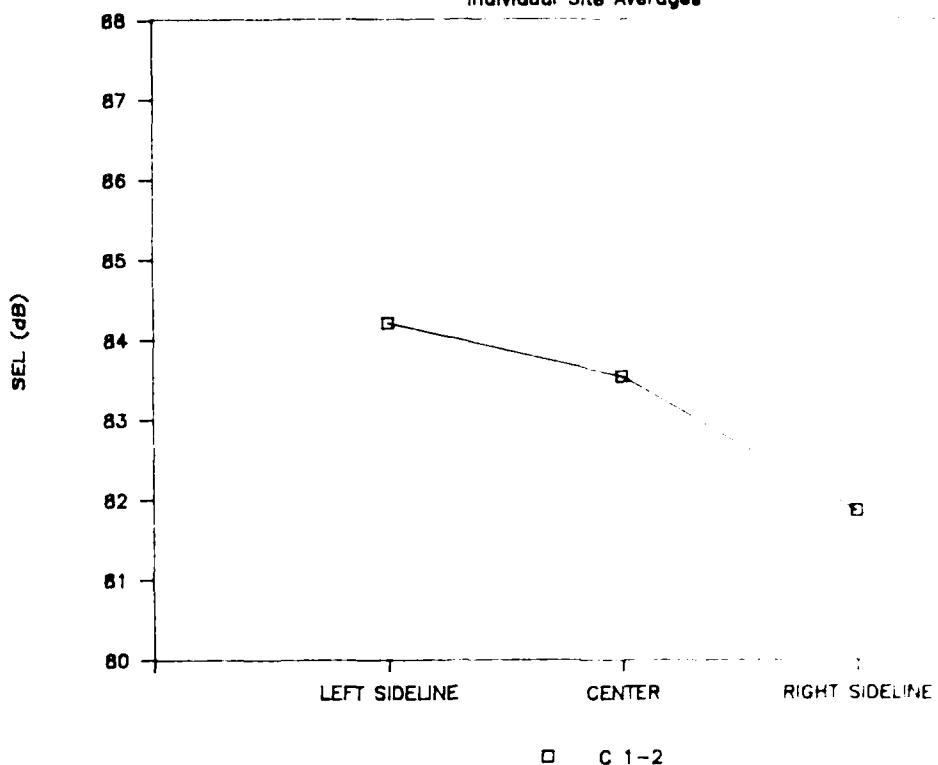
## SEL-TAKEOFF

Individual Site Averages



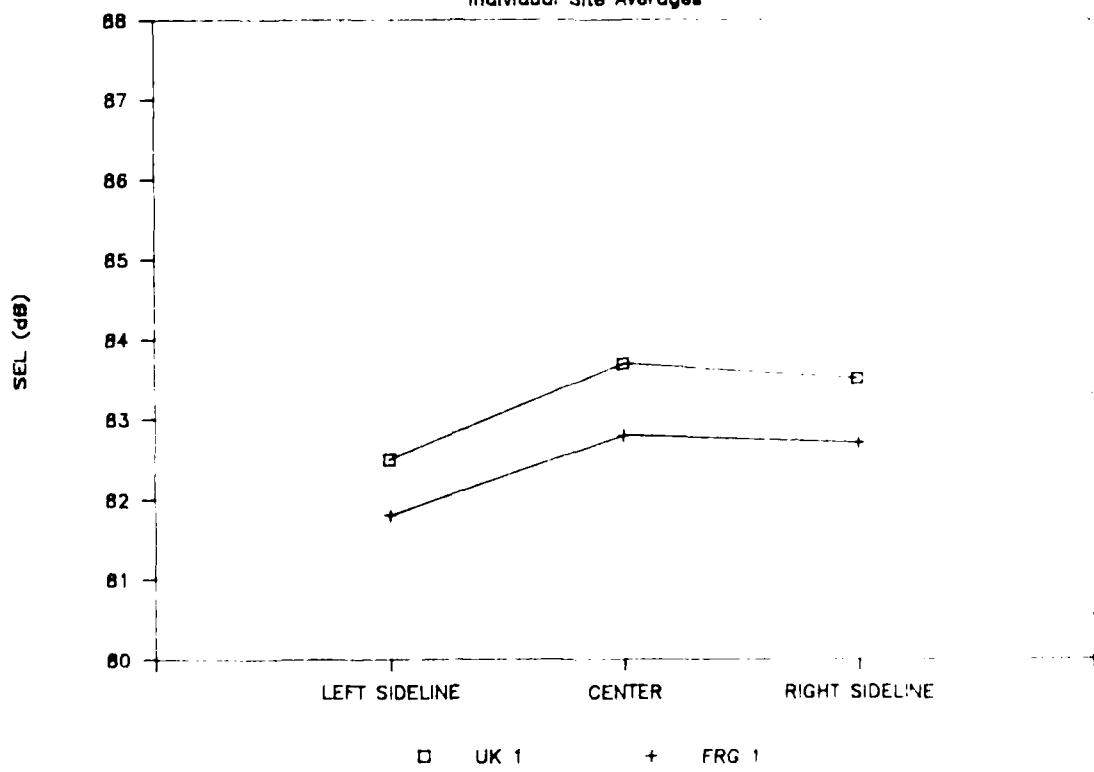
### SEL-TAKEOFF

Individual Site Averages



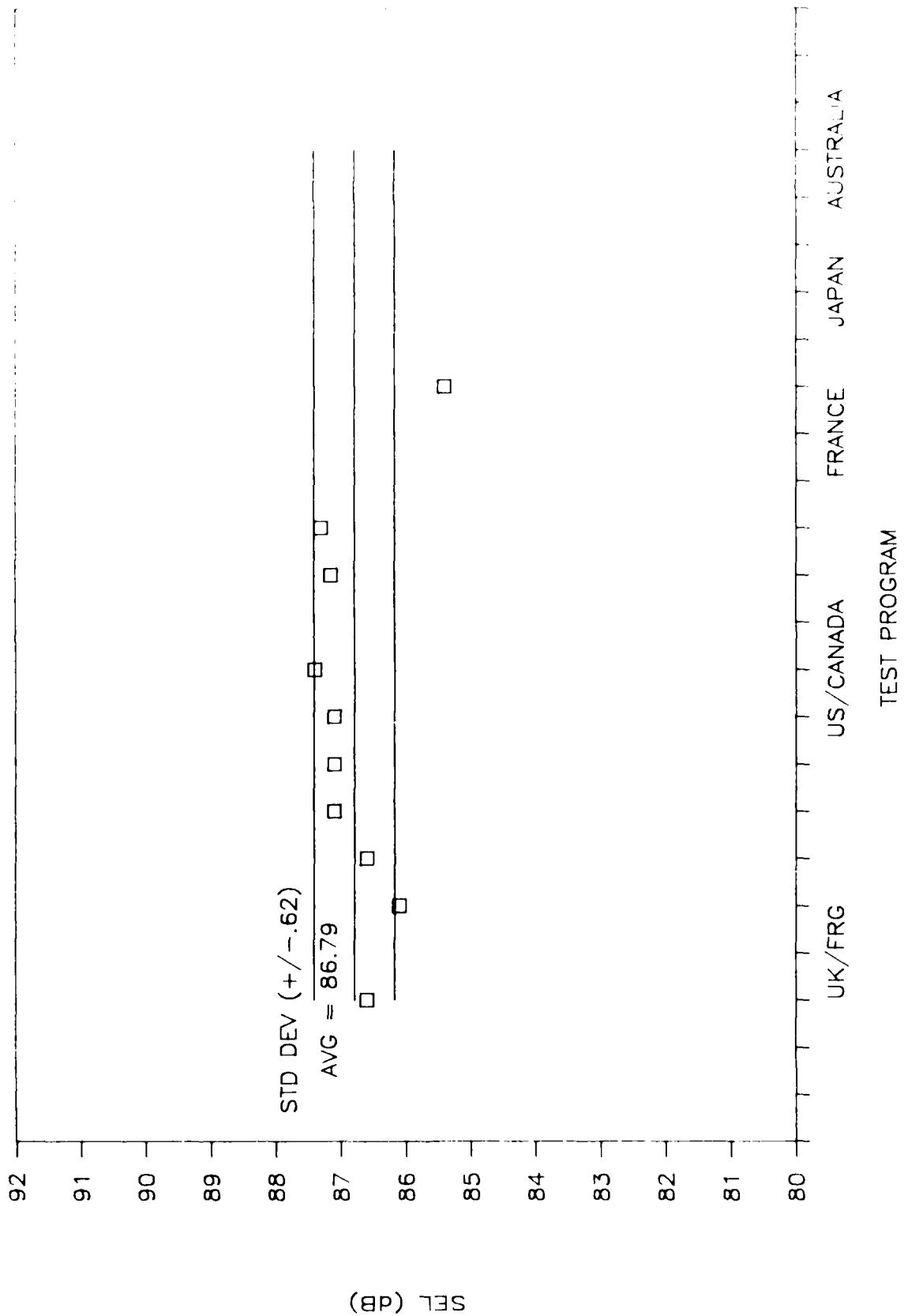
### SEL-TAKEOFF

Individual Site Averages



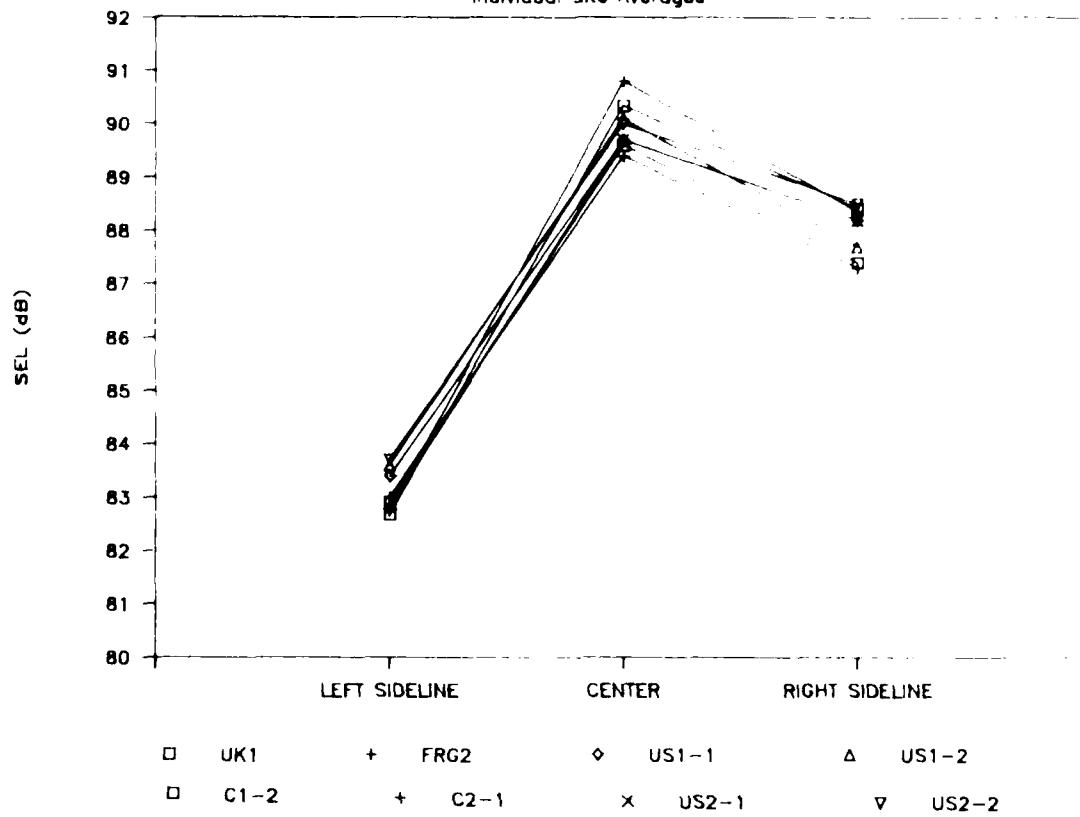


# SEL 3 MIC AVERAGE & STD DEVIATION APPROACH



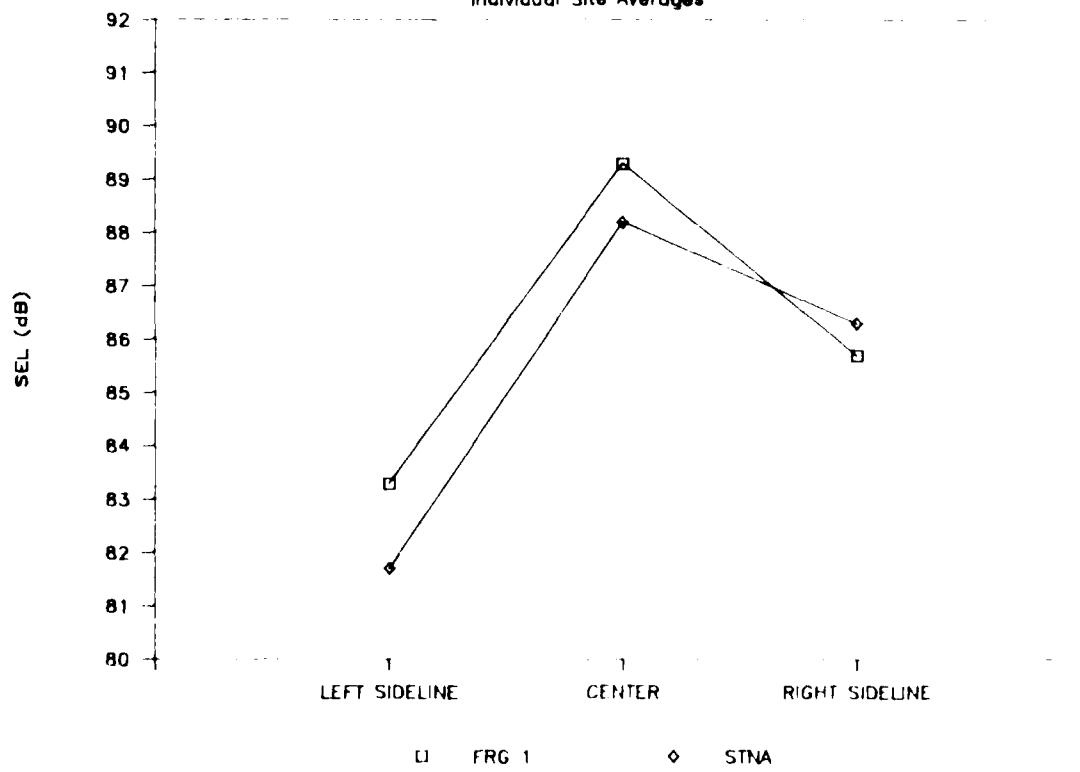
### SEL-APPROACH

Individual Site Averages



### SEL-APPROACH

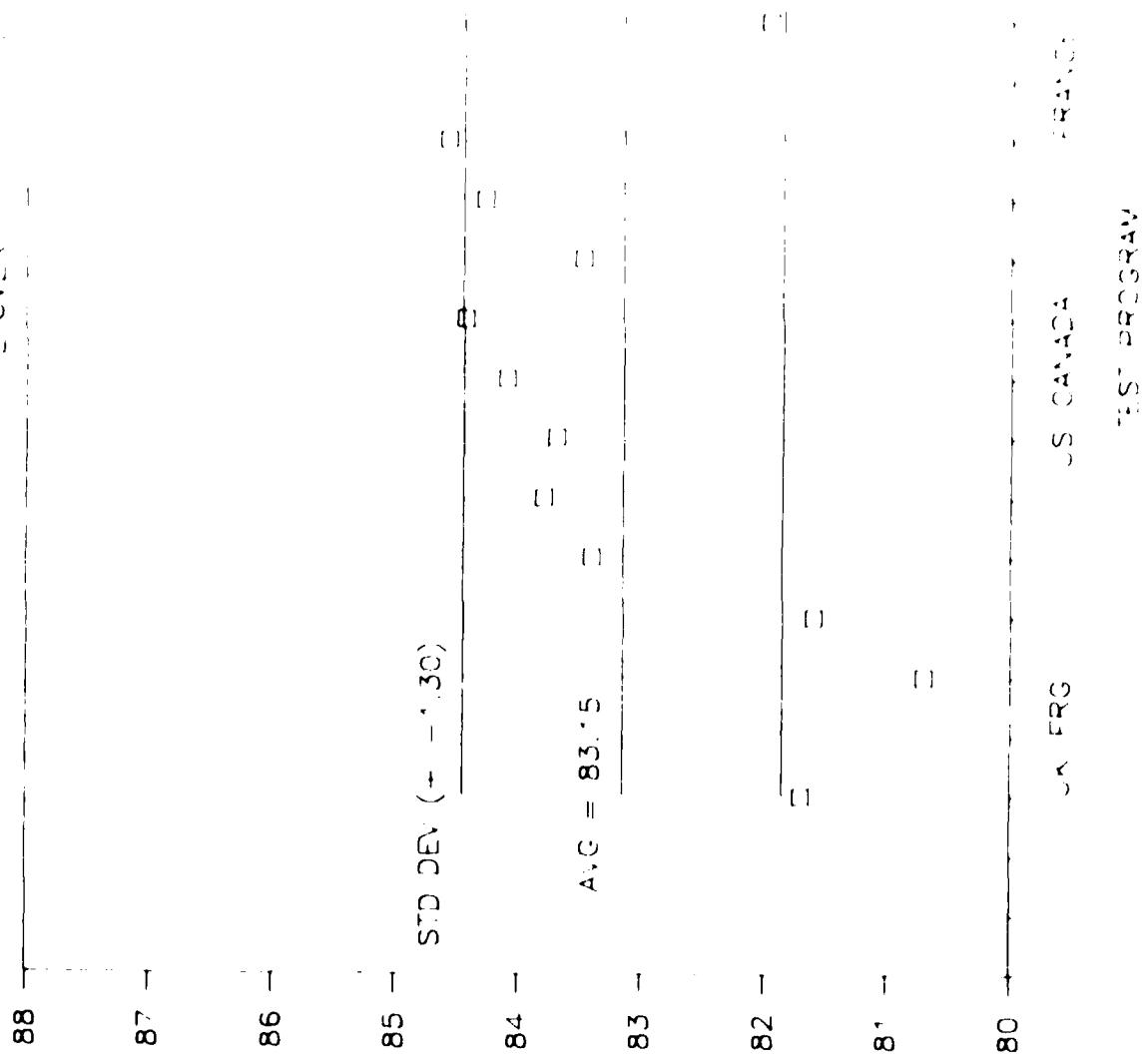
Individual Site Averages

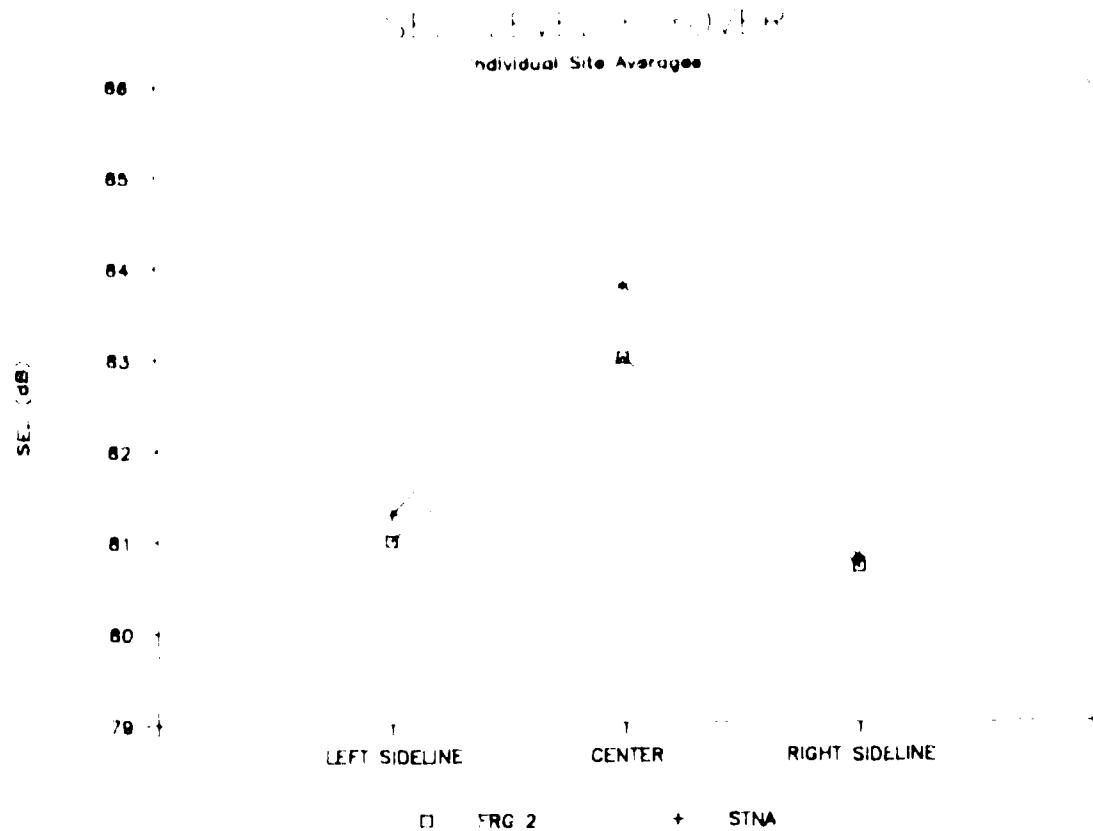
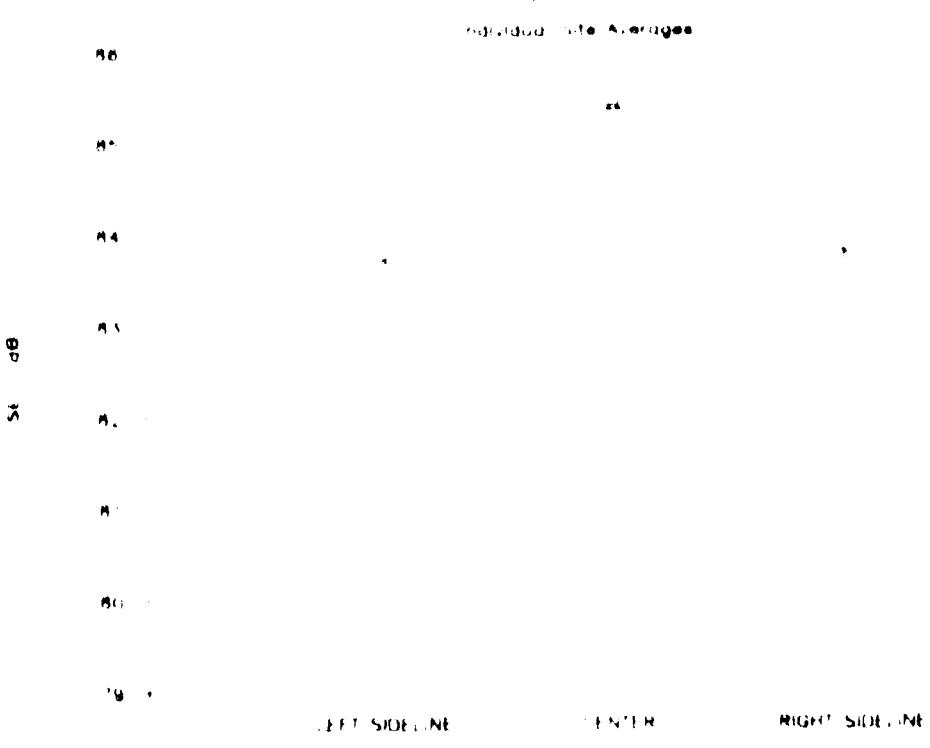


**REVIEW ARTICLE** *How to Write a Book Review* by Michael S. Krasny, University of California, Berkeley

UK delta-3 calculated at 15°C

SE-3 NOISE AVERAGE & STANDARD DEVIATION





1.5 m. Elevation

Individual Site Averages

86

85

84

83

82

81

80

79

LEFT SIDELINE

CENTER

RIGHT SIDELINE

□ US 1-2

+ US 2-1

◊ C 1-1

1.5 m. Elevation

Individual Site Averages

86

85

84

83

82

81

80

79

LEFT SIDELINE

CENTER

RIGHT SIDELINE

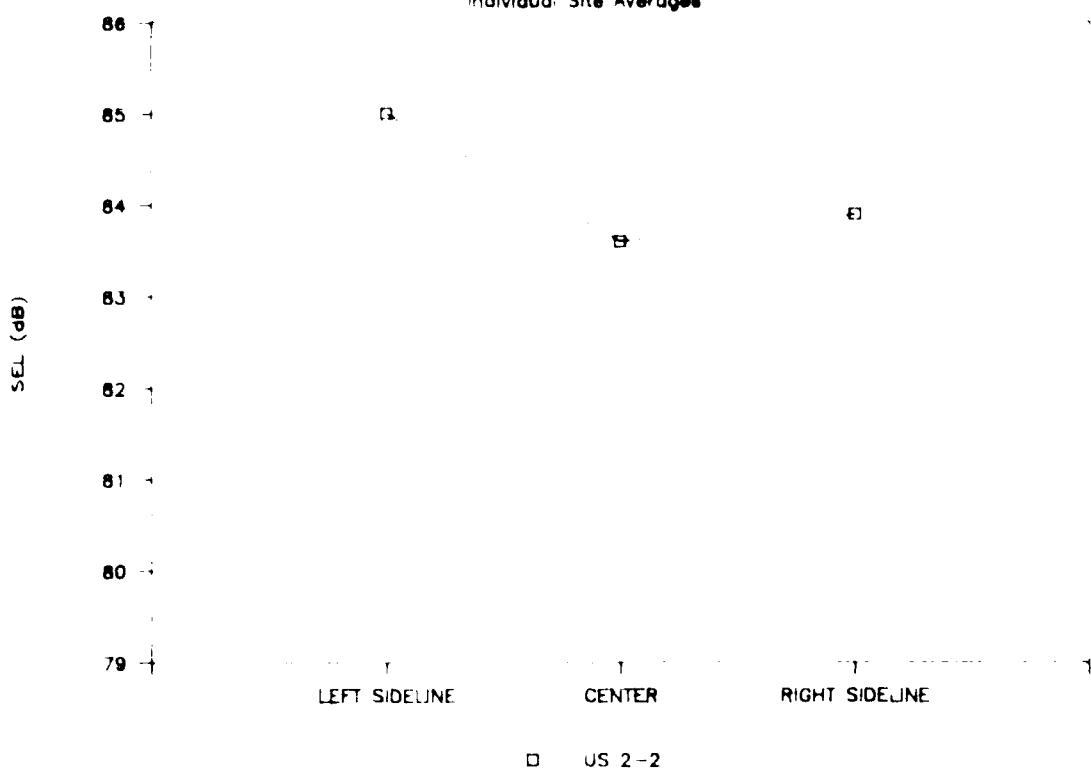
□ US 1-2

+ US 2-1

◊ C 1-1

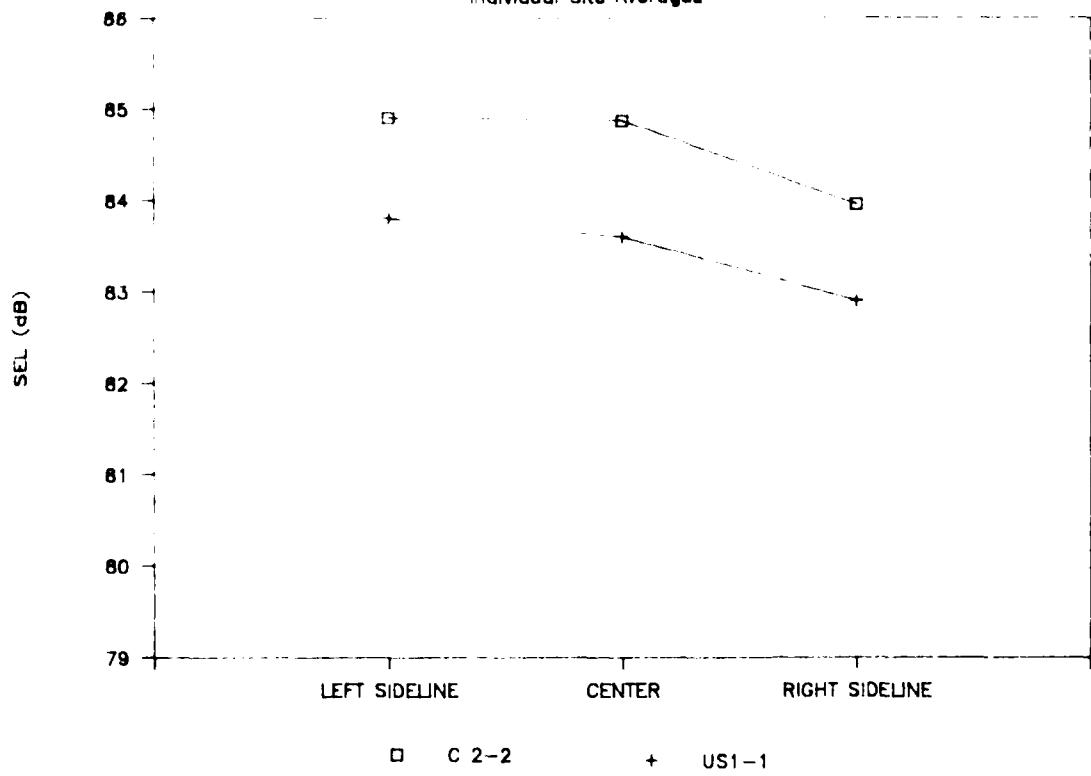
## SEL - LEVEL FLYOVER

Individual Site Averages



## SEL - LEVEL FLYOVER

Individual Site Averages



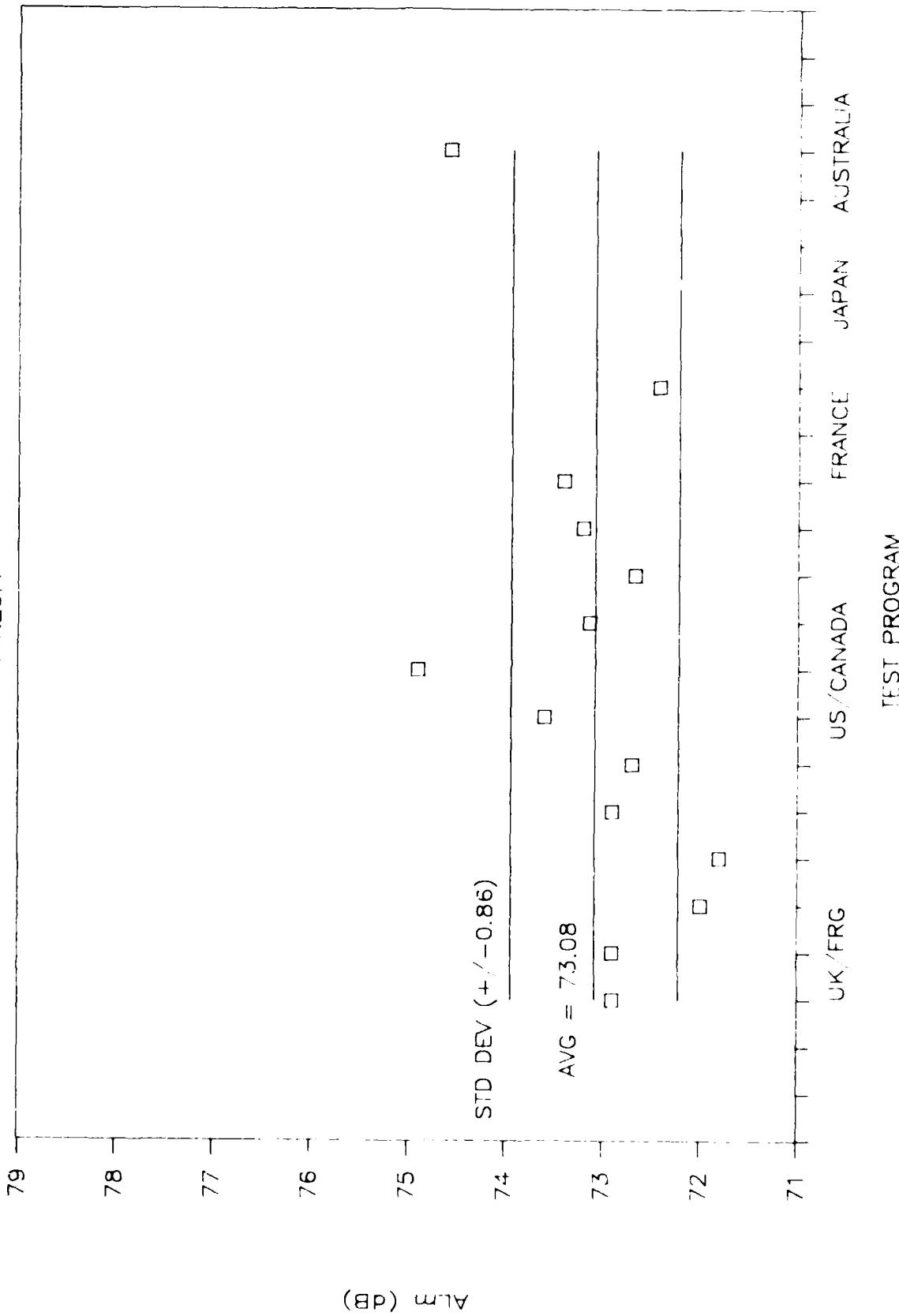
# **ALM Metric Multi-nation Comparison Data**

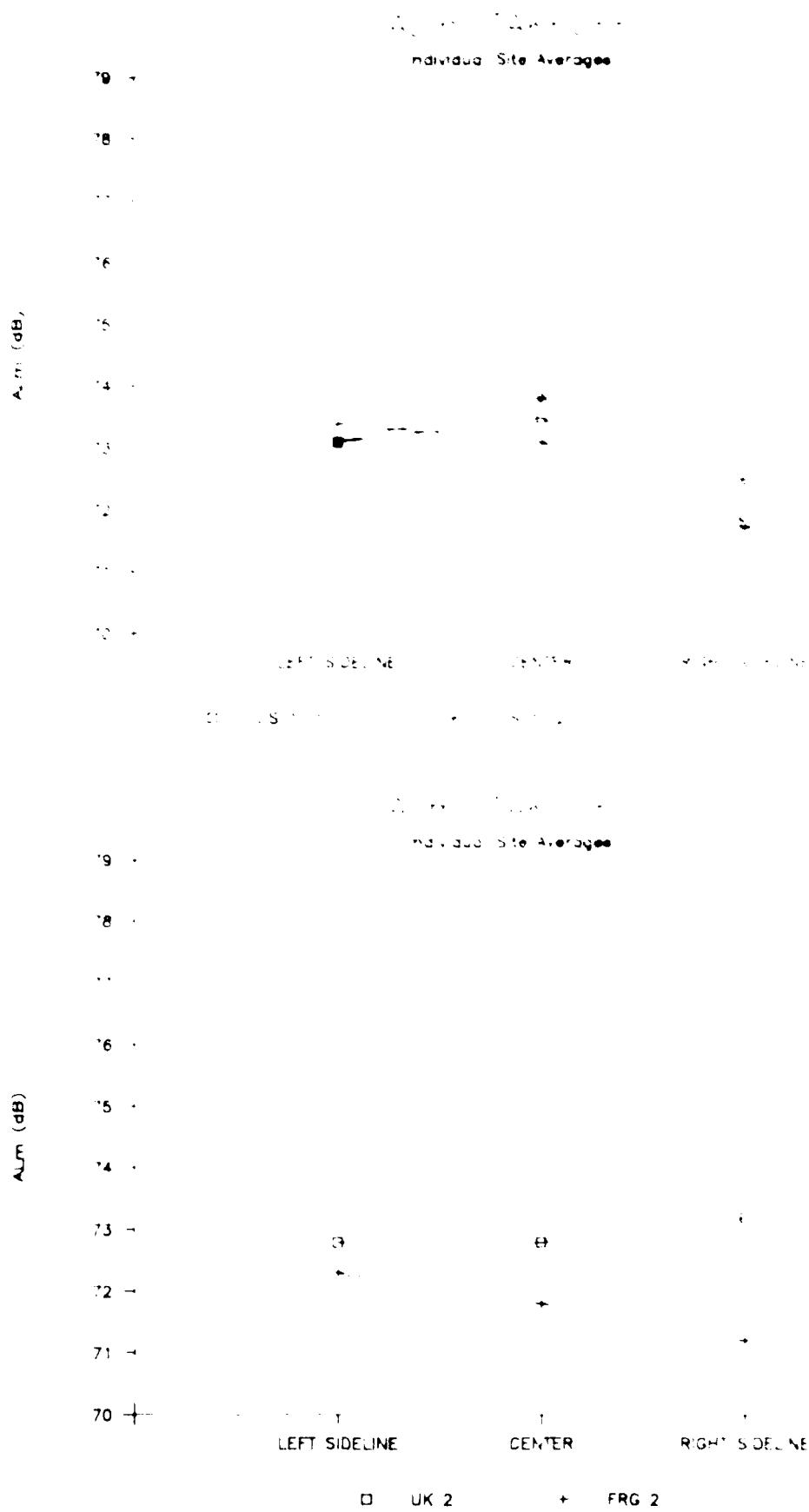
MULTINATIONAL COMPARISON ANALYSIS  
THREE DEF. RUL. DATA EXPRESSED IN DECIBELS AND

| PARTICIPANT                  | LEFT     |         | CENTER   |         | RIGHT    |         | STD DEVI. | STD DEVI. | STD DEVI. |
|------------------------------|----------|---------|----------|---------|----------|---------|-----------|-----------|-----------|
|                              | DEF LINE | AVERAGE | DEF LINE | AVERAGE | DEF LINE | AVERAGE |           |           |           |
| <del>REDACTED</del>          |          |         |          |         |          |         |           |           |           |
| ARMED FORCES OF<br>AUSTRALIA | 71.11    | 71.31   | 74.14    | 74.14   | 74.58    | 74.58   | 0.32      | 0.32      | 0.32      |
| ARMED FORCES<br>BELGIUM      | NH       | NH      | NH       | NH      | NH       | NH      | NH        | NH        | NH        |
| ARMED FORCES<br>CANADA       | NH       | NH      | NH       | NH      | NH       | NH      | 0.38      | 0.38      | 0.38      |
| ARMED FORCES<br>FRANCE       | NH       | NH      | NH       | NH      | NH       | NH      | NH        | NH        | NH        |
| ARMED FORCES<br>FRANCE       | 71.11    | 71.11   | 71.4     | 71.4    | 71.41    | 71.41   | 0.31      | 0.31      | 0.31      |
| ARMED FORCES<br>ITALY        | NH       | NH      | NH       | NH      | NH       | NH      | NH        | NH        | NH        |
| ARMED FORCES<br>JAPAN        | 71.2     | 71.6    | 71.6     | 71.6    | 71.69    | 71.69   | 0.30      | 0.30      | 0.30      |
| ARMED FORCES<br>KOREA        | 71.2     | 71.6    | 71.6     | 71.6    | 71.69    | 71.69   | 0.40      | 0.40      | 0.40      |
| ARMED FORCES<br>MEXICO       | 71.1     | 71.4    | 71.4     | 71.4    | 71.41    | 71.41   | 0.30      | 0.30      | 0.30      |
| ARMED FORCES<br>NETHERLANDS  | 71.11    | 71.8    | 71.8     | 71.8    | 71.89    | 71.89   | 0.30      | 0.30      | 0.30      |
| ARMED FORCES<br>NEW ZEALAND  | 71.11    | 71.82   | 71.45    | 71.45   | 71.14    | 71.14   | 0.18      | 0.18      | 0.18      |
| ARMED FORCES<br>NORWAY       | 71.11    | 74.02   | 71.65    | 71.65   | 71.67    | 71.67   | 0.37      | 0.37      | 0.37      |
| ARMED FORCES<br>PAKISTAN     | 71.14    | 75.04   | 71.50    | 71.50   | 71.21    | 71.21   | 0.81      | 1.18      | 1.18      |
| ARMED FORCES<br>PAKISTAN     | 71.15    | 75.35   | 71.44    | 71.44   | 73.41    | 73.41   | 1.29      | 1.17      | 1.17      |
| ARMED FORCES<br>PHILIPPINES  | 71.19    | 71.56   | 71.51    | 71.51   | 71.59    | 71.59   | 0.45      | 0.31      | 0.31      |
| ARMED FORCES<br>PHILIPPINES  | 71.4     | 71.16   | 71.5     | 71.5    | 71.79    | 71.79   | 0.40      | 0.41      | 0.41      |
| ARMED FORCES<br>SINGAPORE    | 71.40    | 74.59   | 71.51    | 71.51   | 73.62    | 73.62   | 0.42      | 0.45      | 0.45      |
| ARMED FORCES<br>SOUTH KOREA  | 74.86    | 76.21   | 72.79    | 72.79   | 74.96    | 74.96   | 0.73      | 0.61      | 0.61      |
| <del>REDACTED</del>          |          |         |          |         |          |         |           |           |           |
| AVERAGE                      | 71.89    | 74.11   | 71.71    | 71.71   | 72.08    | 72.08   | 0.50      | 0.54      | 0.54      |
| STD DEVI.                    | 0.97     | 1.05    | 1.07     | 1.07    | 0.86     | 0.86    | 0.72      | 0.56      | 0.56      |
| STD DEVI.                    | 0.97     | 0.96    | 0.71     | 0.71    | 0.81     | 0.81    | 0.23      | 0.49      | 0.49      |

# ALM 3 MIC AVERAGE & STD DEVIATION

TAKEOFF





4. m - TAKEOFF

Individual Site Averages

LEFT SIDELINE

CENTER

RIGHT SIDELINE

• AUS                    • OK                    • ERG 1

♦ STNA

Individual Site Averages

LEFT SIDELINE

CENTER

RIGHT SIDELINE

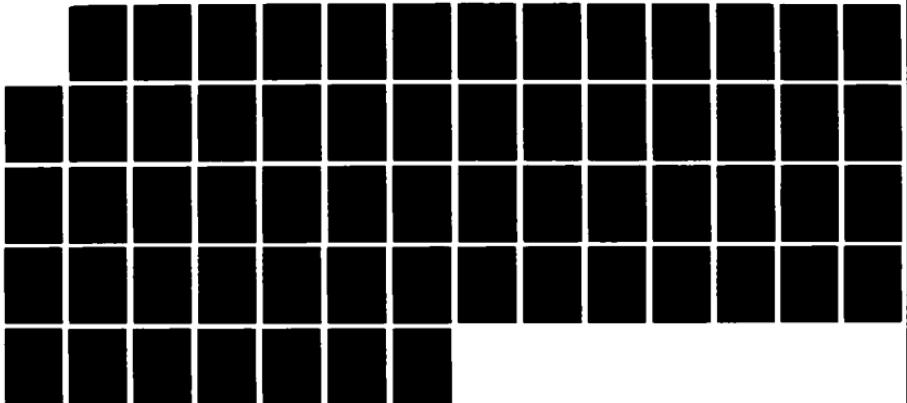
• AUS

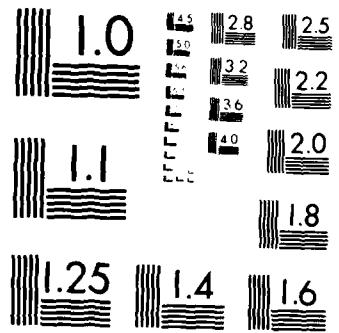
• OK

♦ ERG 1

10-8100 540 INTERNATIONAL CIVIL AVIATION ORGANIZATION COMMITTEE ON  
AVIATION ENVIRONMENT. (U) FEDERAL AVIATION ADMINISTRATION  
WASHINGTON DC OFFICE OF ENVIR. J S NEWMAN ET AL.  
UNCLASSIFIED SEP 87 FRA-EE-87-2

3/3  
F/G 20/1 NL

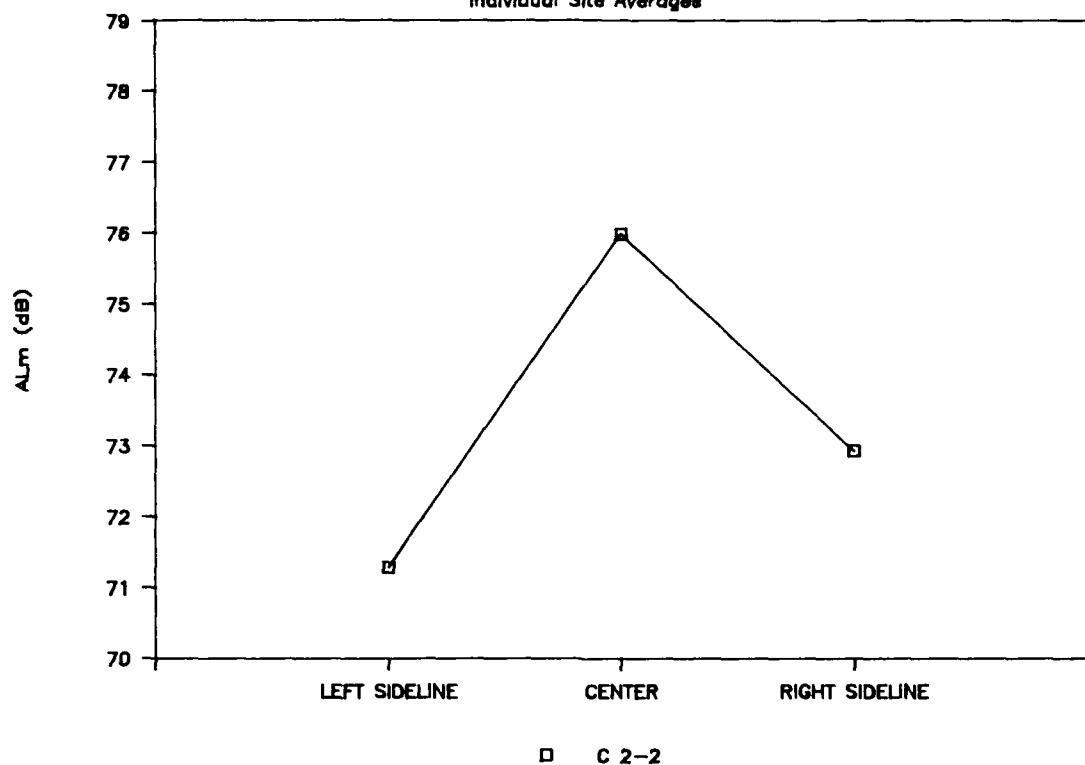




MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS 1963 A

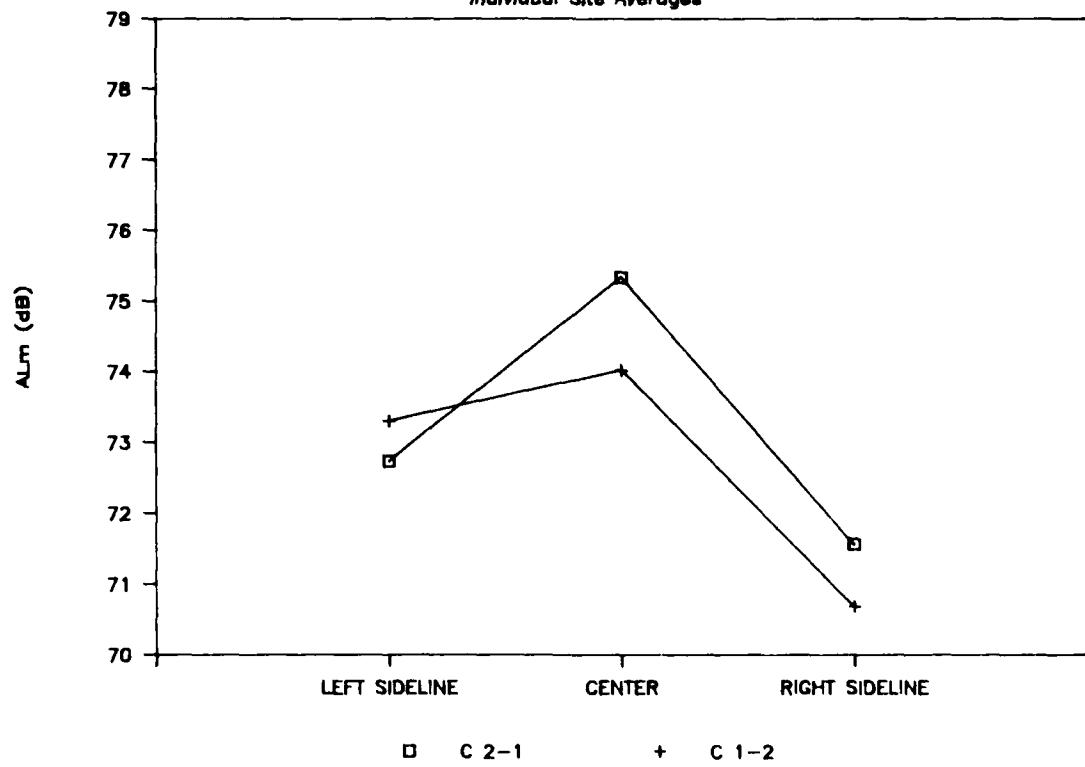
### ALm-TAKEOFF

Individual Site Averages



### ALm-TAKEOFF

Individual Site Averages

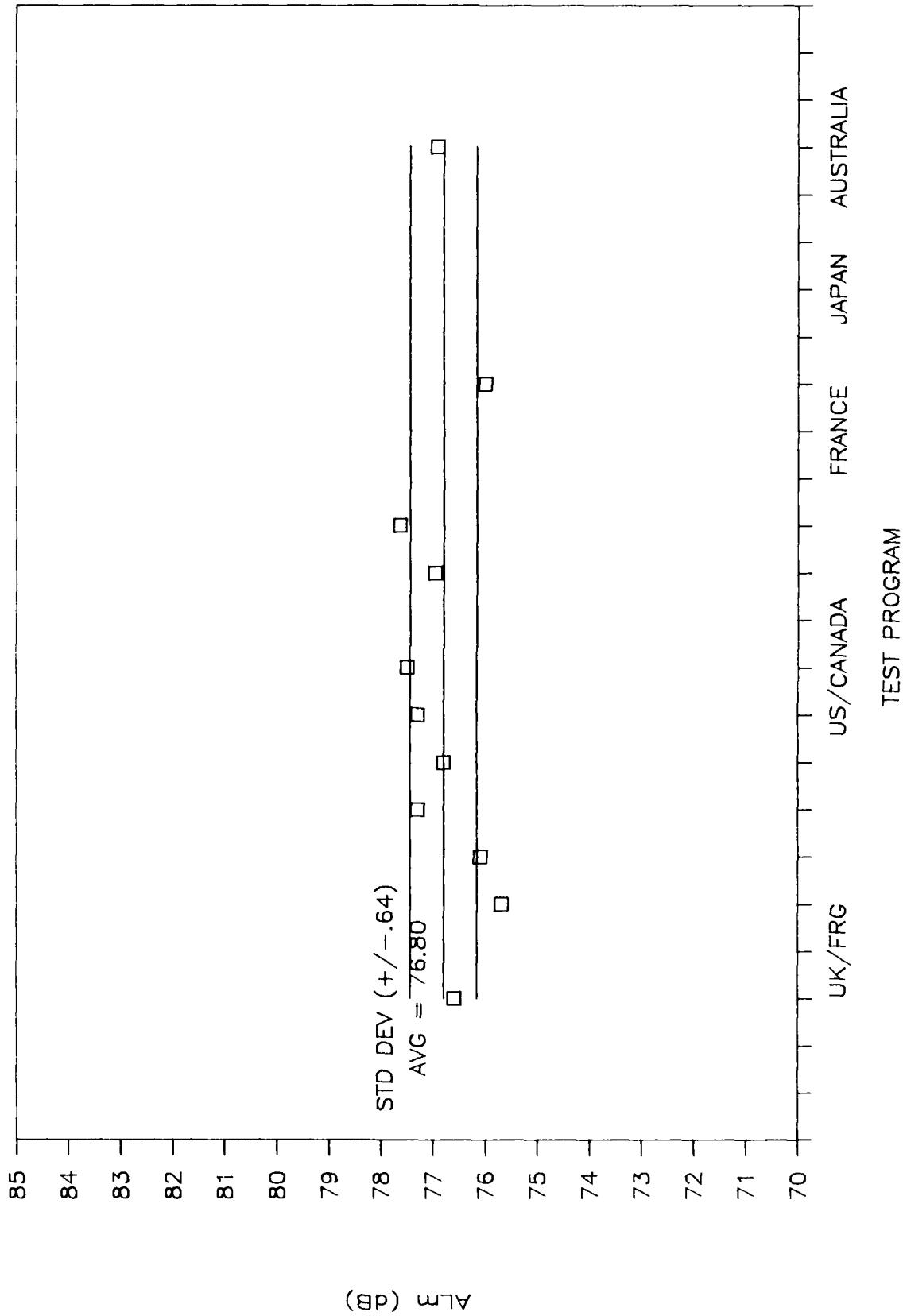


MULTI-NATION COMPARISON ANALYSIS  
APPROACH ALM DATA EXPRESSED IN DECIBELS (dB)

| PARTICIPANT      | LEFT                | CENTER            | LINE                | RIGHT           | 3 MIC<br>AVERAGE | STD<br>DEV | 90% C.I. | TEAM            | TEST            |
|------------------|---------------------|-------------------|---------------------|-----------------|------------------|------------|----------|-----------------|-----------------|
|                  | SIDELINE<br>AVERAGE | CENTER<br>AVERAGE | SIDELINE<br>AVERAGE | TEAM<br>AVERAGE |                  |            |          | TEAM<br>AVERAGE | TEST<br>AVERAGE |
| AUSTRALIA        | 71.95               | 80.80             | 77.99               | 76.92           | 1.11             | 0.74       | 76.92    | 76.92           |                 |
| JAPAN-PILOT 1    | NA                  | NA                | NA                  | NA              |                  |            |          |                 |                 |
| JAPAN-PILOT 2    | NA                  | NA                | NA                  | NA              |                  |            |          |                 |                 |
| FRANCE-AERO      | NA                  | NA                | NA                  | NA              |                  |            |          |                 |                 |
| FRANCE-STNA      | 71.50               | 79.90             | 76.50               | 76.00           | 1.20             | 0.90       | 76.00    |                 |                 |
| ITALY            | NA                  | NA                | NA                  | NA              |                  |            |          |                 |                 |
| FRG-PILOT 1      | 71.20               | 80.90             | 75.10               | 75.70           | 0.50             | 0.30       | 75.90    | 76.13           |                 |
| FRG-PILOT 2      | 71.40               | 80.70             | 76.40               | 76.10           | 0.50             | 0.40       | 76.60    |                 |                 |
| UK-PILOT 1       | 71.90               | 81.20             | 76.50               | 76.60           | 0.90             | 0.70       | 76.60    |                 |                 |
| CANADA-PILOT 1-2 | 71.35               | 82.25             | 77.32               | 76.97           | 0.12             | 0.53       | 77.31    | 77.25           |                 |
| CANADA-PILOT 2-1 | 71.78               | 83.52             | 77.65               | 77.64           | 0.47             | 0.79       | 77.23    |                 |                 |
| US-PILOT 1-1     | 72.50               | 81.70             | 77.60               | 77.30           | 0.82             | 0.55       | 77.23    |                 |                 |
| US-PILOT 1-2     | 72.20               | 81.50             | 76.80               | 76.80           | 0.49             | 0.46       |          |                 |                 |
| US-PILOT 2-1     | 71.66               | 81.90             | 78.10               | 77.30           | 0.54             | 0.40       |          |                 |                 |
| US-PILOT 2-2     | 72.80               | 81.60             | 78.40               | 77.50           | 0.58             | 0.38       |          |                 |                 |
| AVERAGE          | 71.81               | 81.45             | 77.12               | 76.80           | 0.66             | 0.56       | 76.66    | 76.77           |                 |
| STD DEV          | 0.47                | 0.95              | 0.97                | 0.64            | 0.32             | 0.20       | 0.60     | 0.57            |                 |
| 90% C.I.         | 0.39                | 0.79              | 0.81                | 0.53            | 0.26             | 0.16       | 0.83     | 2.31            |                 |

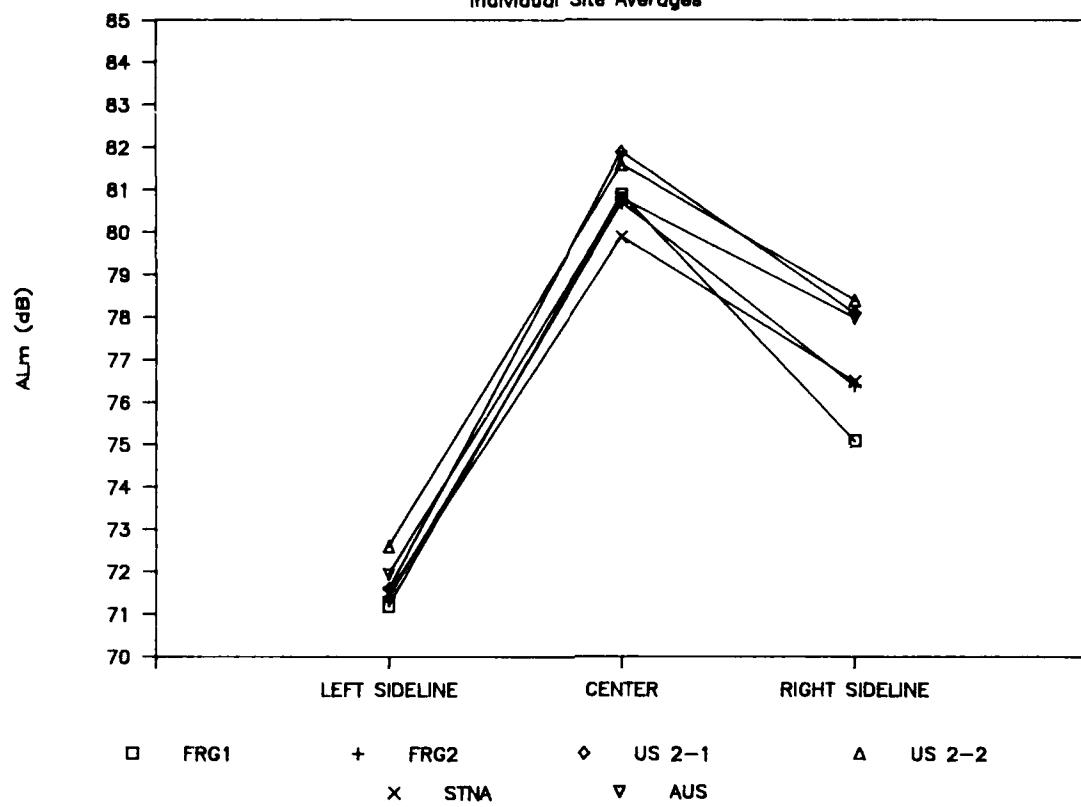
# ALM 3 MIC AVERAGE & STD DEVIATION

APPROACH



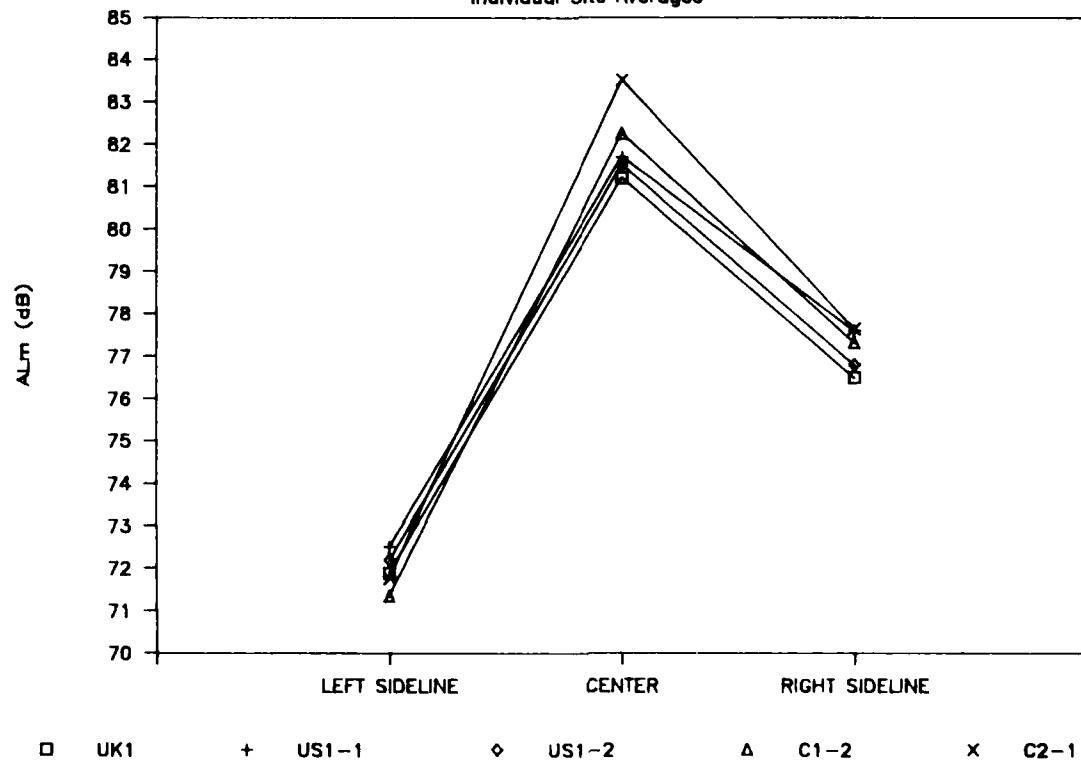
### ALm-APPROACH

Individual Site Averages



### ALm-APPROACH

Individual Site Averages



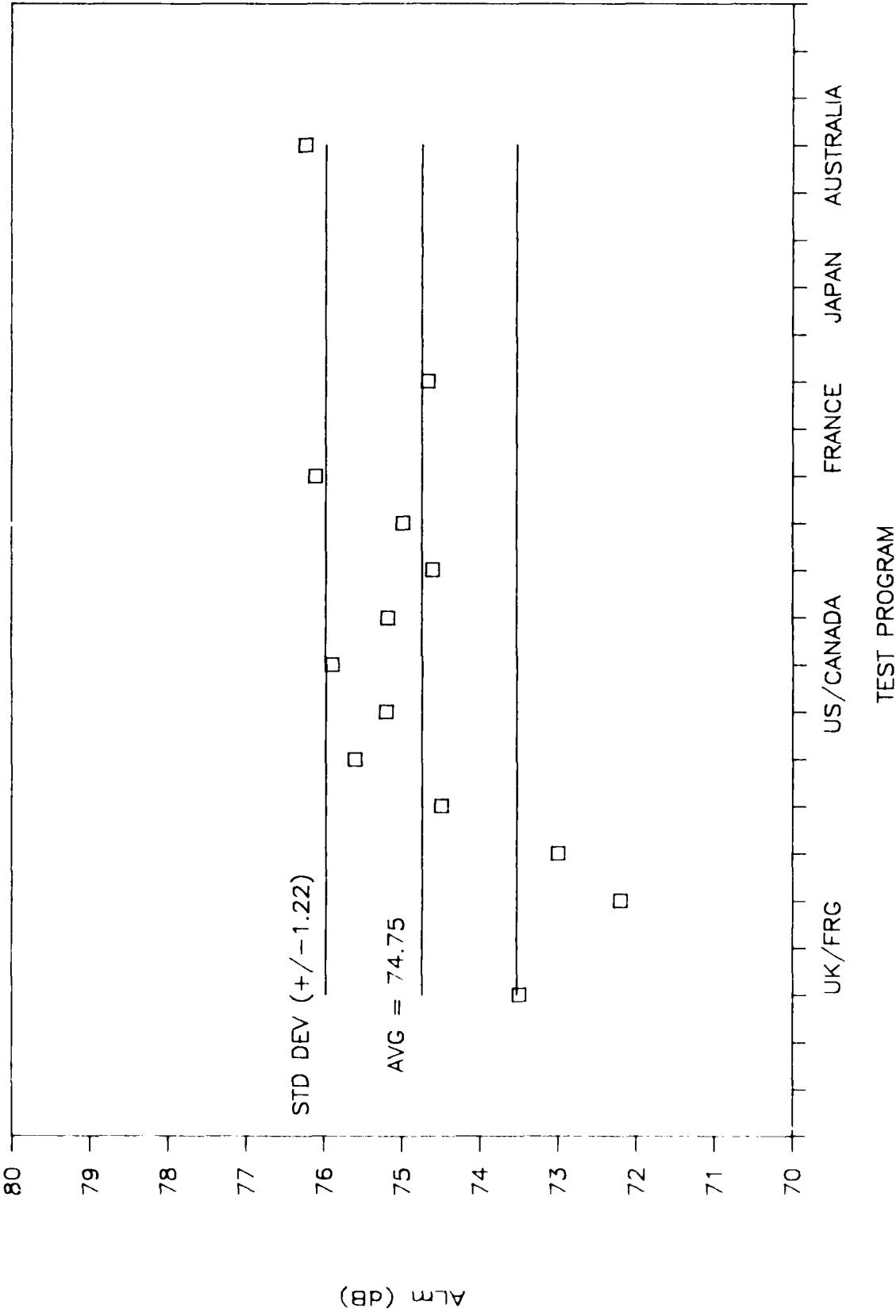
MULTI-NATION COMPARISON ANALYSIS  
LEVEL FLYOVER ALM DATA EXPRESSED IN DECIBELS (dB)

| PARTICIPANT      | LEFT                | CENTER            | LINE                | RIGHT | 3 MIC<br>AVERAGE | STD<br>DEV | 90% C.I. | TEAM<br>AVERAGE | TEST<br>AVERAGE |
|------------------|---------------------|-------------------|---------------------|-------|------------------|------------|----------|-----------------|-----------------|
|                  | SIDELINE<br>AVERAGE | CENTER<br>AVERAGE | SIDELINE<br>AVERAGE |       |                  |            |          |                 |                 |
| AUSTRALIA        | 75.69               | 78.26             | 74.74               | 76.24 | 0.56             | 0.31       | 76.24    | 76.24           | 76.24           |
| JAPAN-PILOT 1-1  | NA                  | NA                | NA                  | NA    | NA               | NA         | NA       | NA              | NA              |
| JAPAN-PILOT 1-2  | NA                  | NA                | NA                  | NA    | NA               | NA         | NA       | NA              | NA              |
| JAPAN-PILOT 2-1  | NA                  | NA                | NA                  | NA    | NA               | NA         | NA       | NA              | NA              |
| JAPAN-PILOT 2-2  | NA                  | NA                | NA                  | NA    | NA               | NA         | NA       | NA              | NA              |
| FRANCE-AERO      | NA                  | NA                | NA                  | NA    | NA               | NA         | NA       | NA              | NA              |
| FRANCE-STNA      | 73.70               | 77.00             | 73.30               | 74.67 | 0.50             | 0.50       | 74.67    | 74.67           | 74.67           |
| ITALY            | NA                  | NA                | NA                  | NA    | NA               | NA         | NA       | NA              | NA              |
| FRG-PILOT 1      | 71.50               | 74.00             | 71.10               | 72.20 | 0.30             | 0.30       | 72.60    | 72.90           | 72.90           |
| FRG-PILOT 2      | 71.90               | 75.20             | 71.80               | 73.00 | 0.80             | 0.70       | 73.50    | 73.50           | 73.50           |
| UK-PILOT 1       | 72.80               | 75.40             | 72.30               | 73.50 | 0.30             | 0.20       | 73.50    | 73.50           | 73.50           |
| CANADA-PILOT 1-1 | 74.29               | 76.43             | 74.82               | 75.18 | 0.48             | 0.46       | 75.22    | 75.26           | 75.26           |
| CANADA-PILOT 1-2 | 73.94               | 76.68             | 73.02               | 74.61 | 0.59             | 0.81       | 75.30    | 75.30           | 75.30           |
| CANADA-PILOT 2-1 | 74.02               | 77.24             | 73.71               | 74.99 | 0.14             | 0.61       | 75.30    | 75.30           | 75.30           |
| CANADA-PILOT 2-2 | 76.16               | 77.36             | 74.63               | 76.11 | 0.93             | 1.10       | 77.50    | 77.50           | 77.50           |
| US-PILOT 1-1     | 73.90               | 75.60             | 73.90               | 74.50 | 0.26             | 0.19       | 75.30    | 75.30           | 75.30           |
| US-PILOT 1-2     | 75.30               | 76.80             | 74.70               | 75.60 | 0.17             | 0.20       | 77.50    | 77.50           | 77.50           |
| US-PILOT 2-1     | 74.90               | 76.40             | 74.50               | 75.20 | 0.36             | 0.30       | 77.50    | 77.50           | 77.50           |
| US-PILOT 2-2     | 76.20               | 76.10             | 75.50               | 75.90 | 0.59             | 0.36       | 77.50    | 77.50           | 77.50           |
| AVERAGE          | 74.18               | 76.36             | 73.71               | 74.75 | 0.47             | 0.46       | 74.59    | 74.89           | 74.89           |
| STD DEV          | 1.49                | 1.11              | 1.34                | 1.22  | 0.24             | 0.27       | 1.33     | 1.72            | 1.72            |
| 90% C.I.         | 1.11                | 0.82              | 0.99                | 0.90  | 0.18             | 0.20       | 1.82     | 6.90            | 6.90            |

UK delta 3 calculated at 15°C

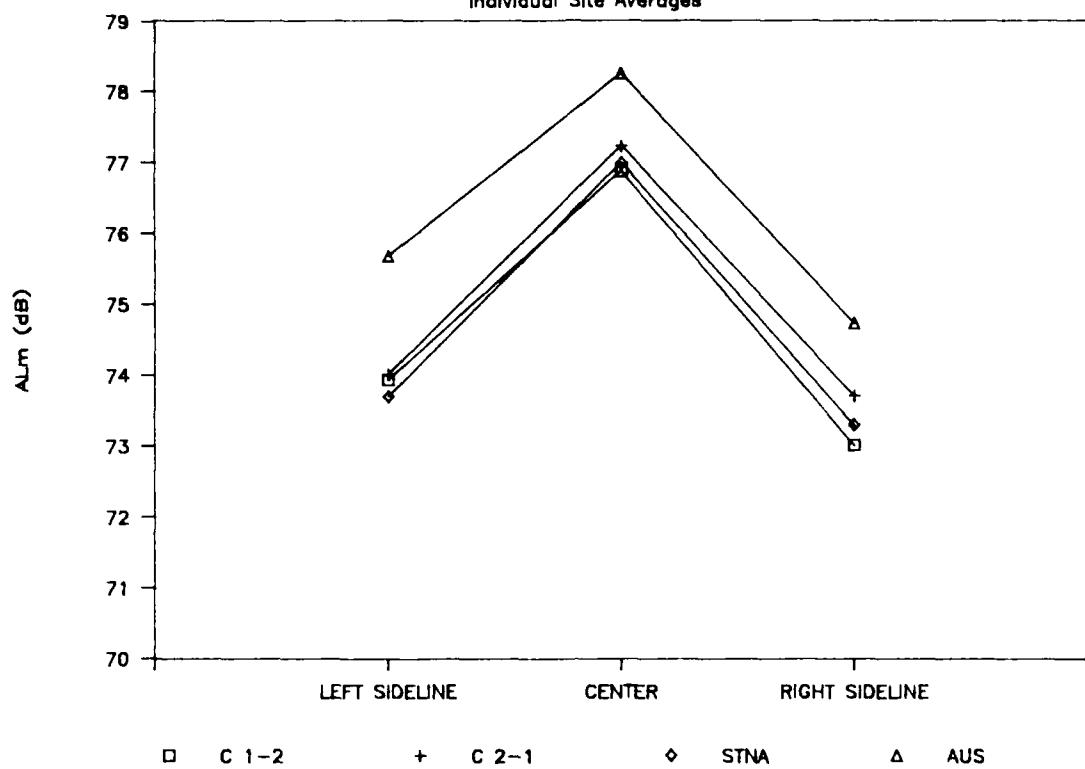
# ALM 3 MIC AVERAGE & STD DEVIATION

FLYOVER            UK delta 3 calculated at 15°C



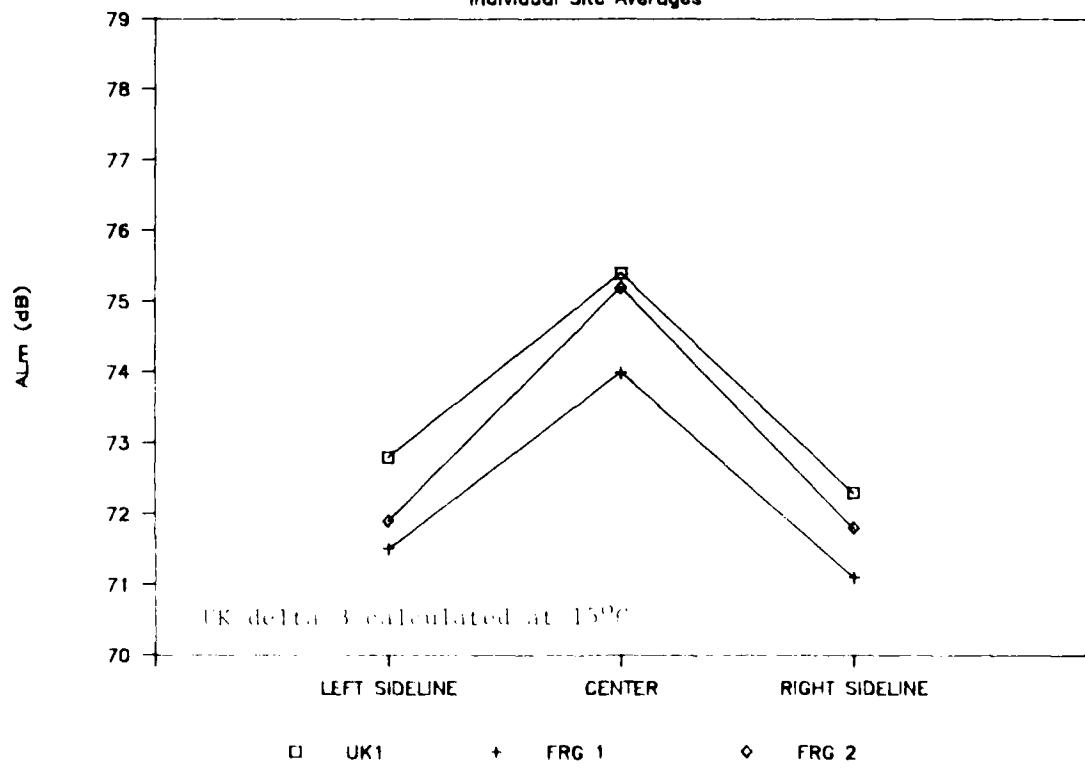
### ALm-LEVEL FLYOVER

Individual Site Averages



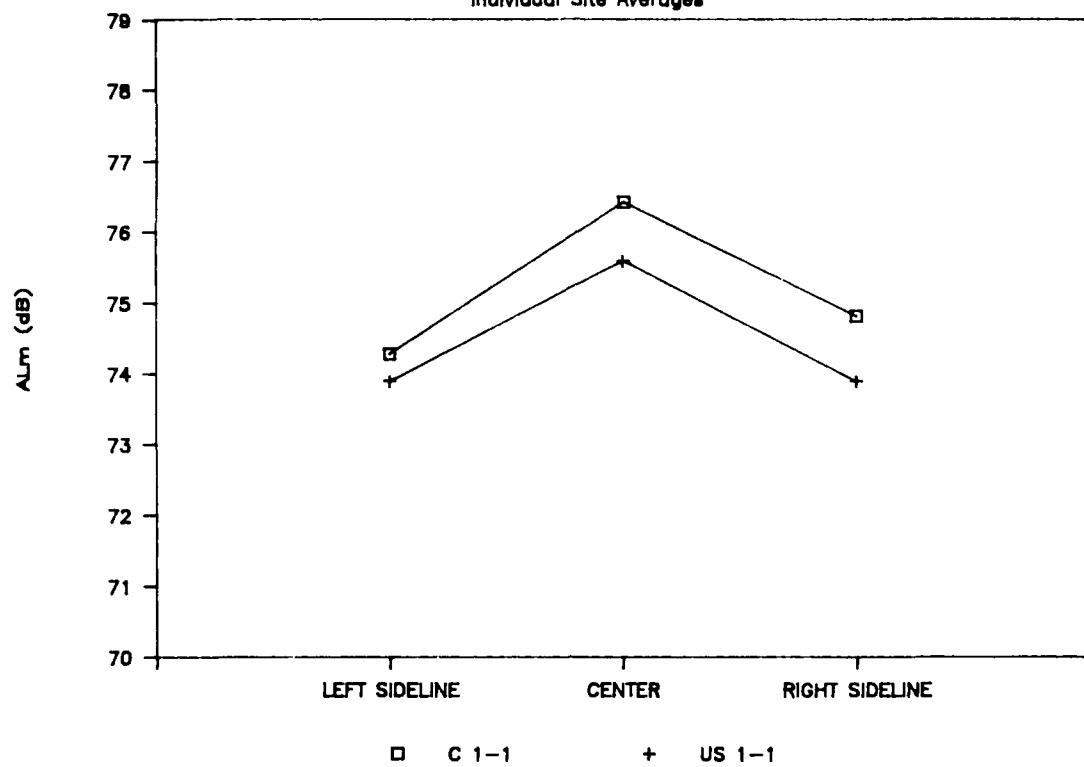
### ALm-LEVEL FLYOVER

Individual Site Averages



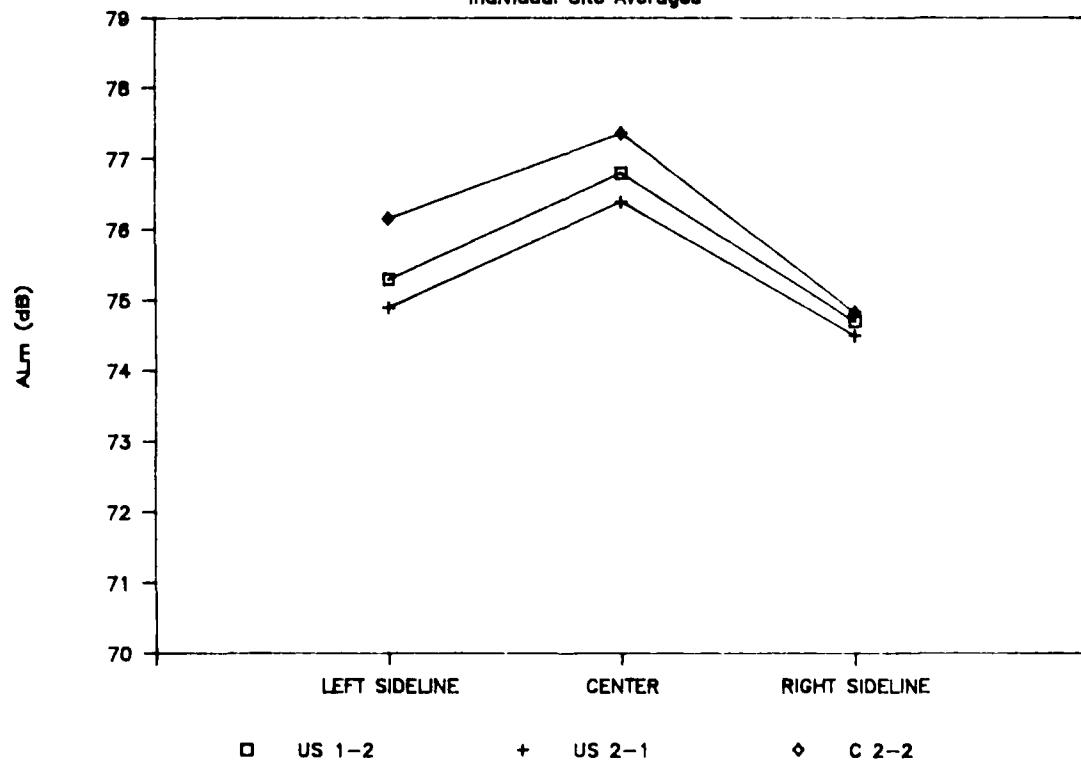
### ALm-LEVEL FLYOVER

Individual Site Averages



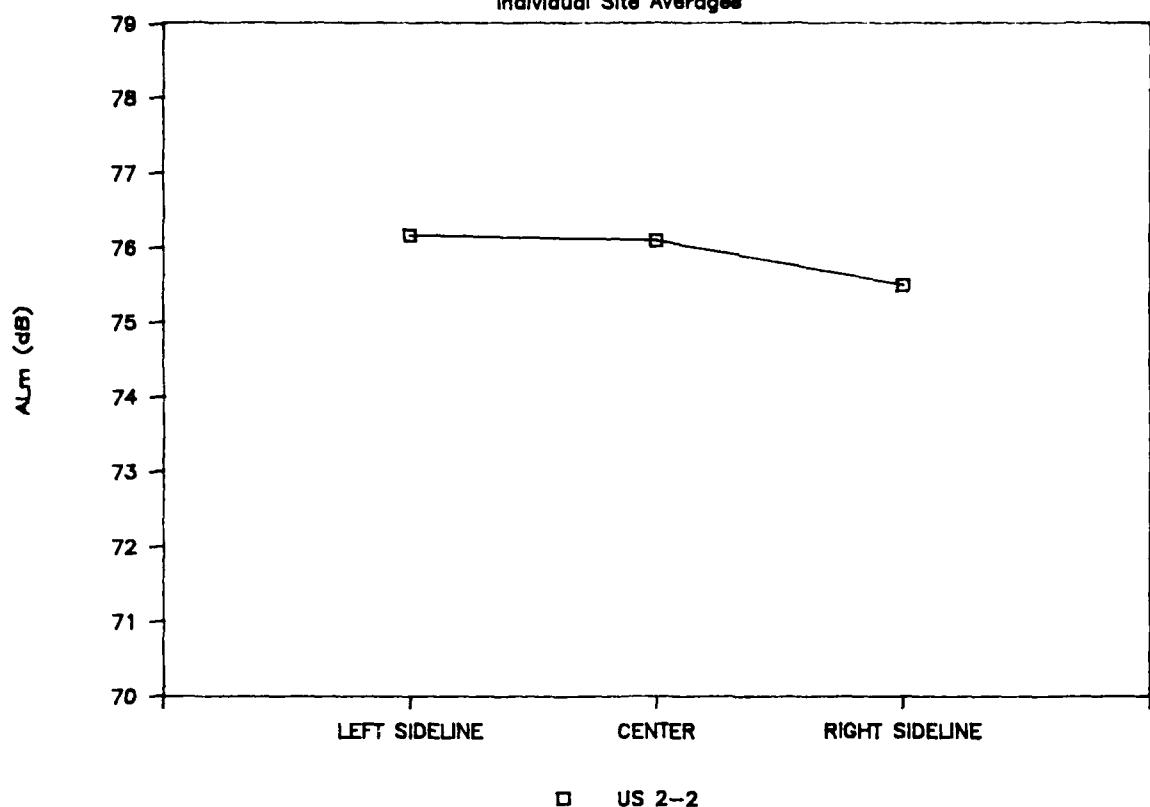
### ALm-LEVEL FLYOVER

Individual Site Averages



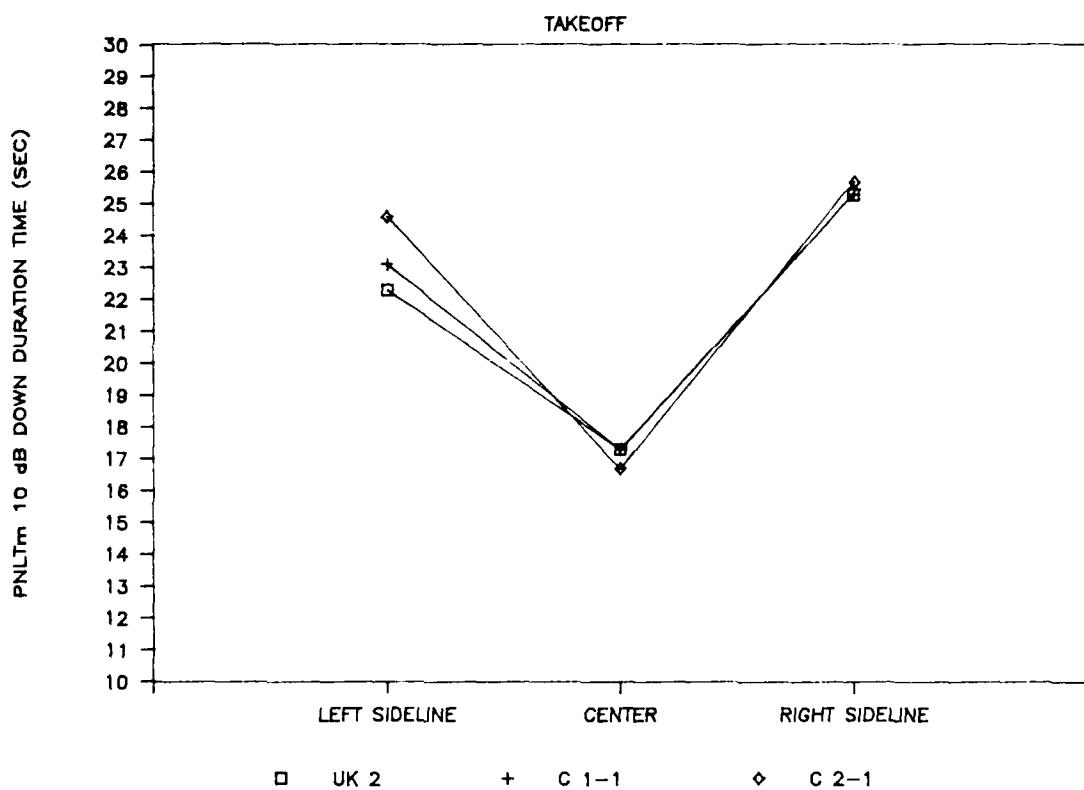
## ALm-LEVEL FLYOVER

Individual Site Averages

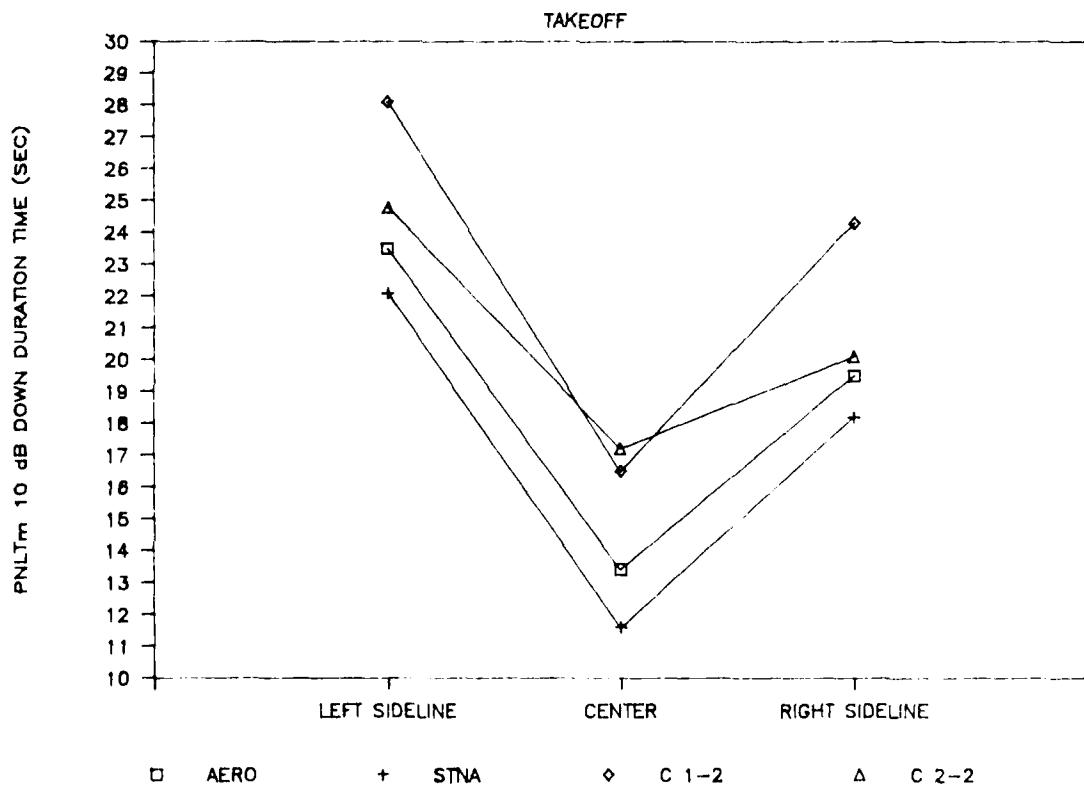


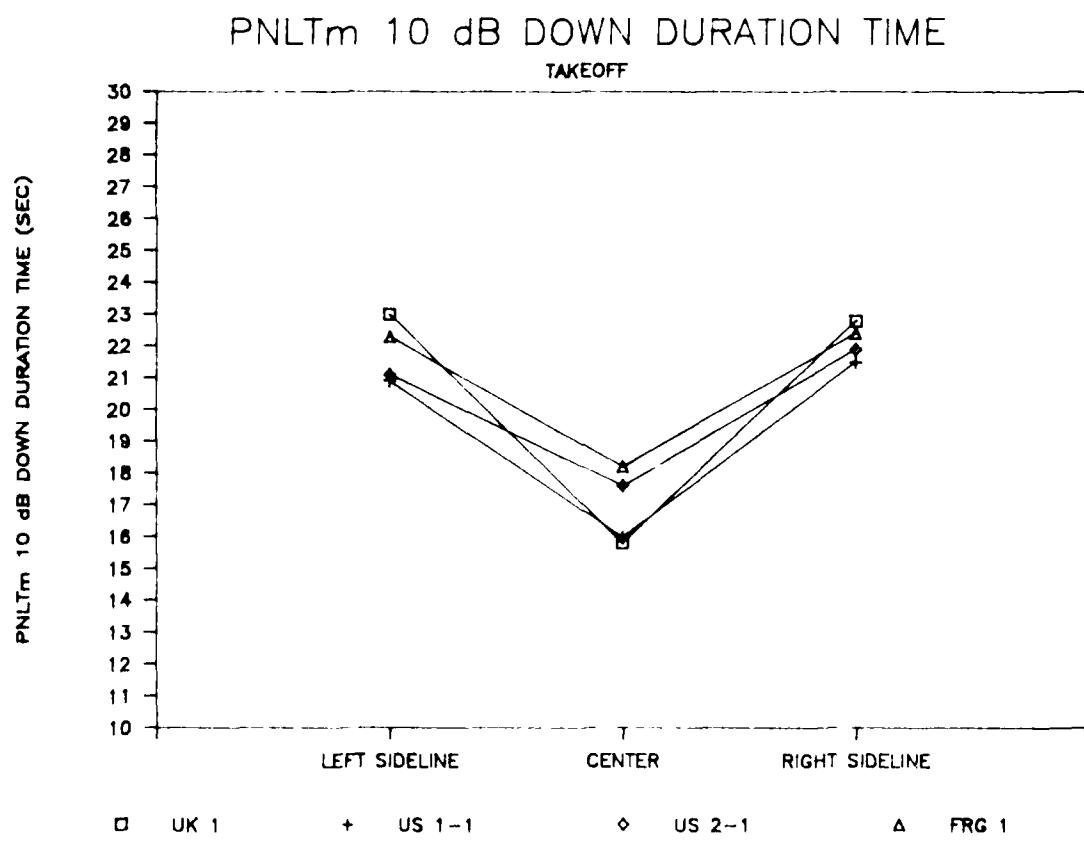
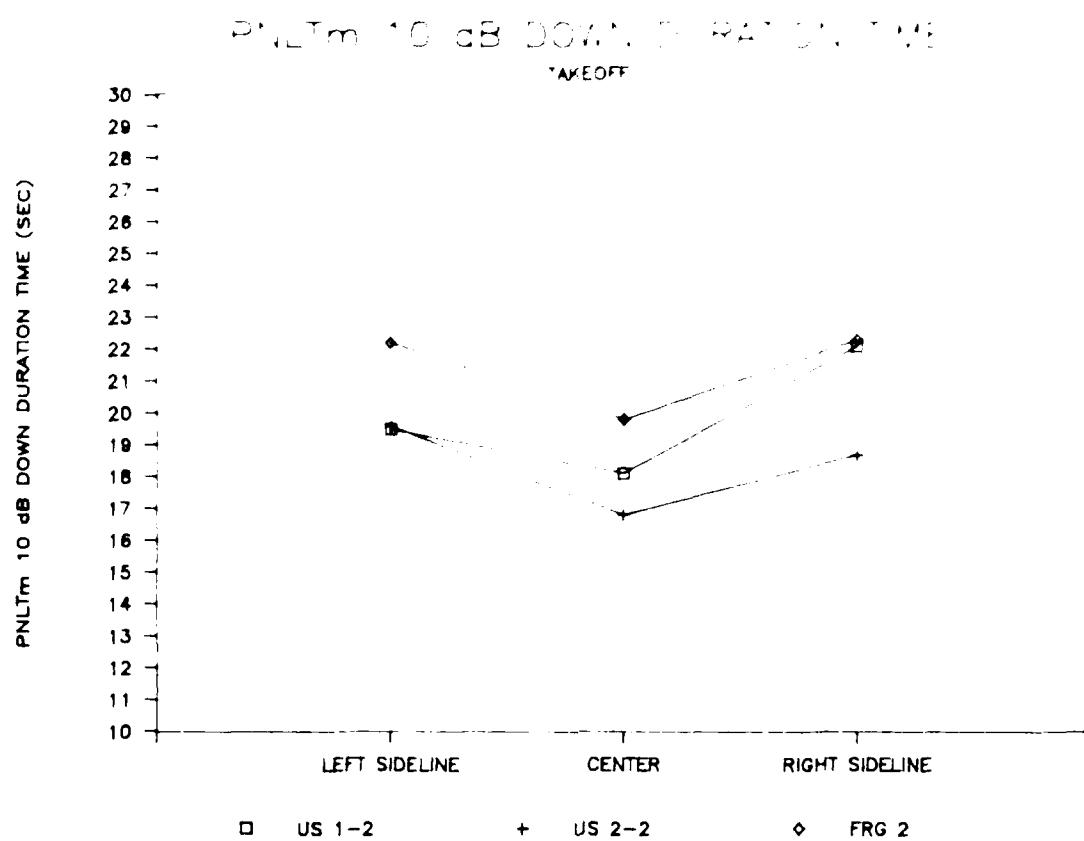
## **Duration Time Data**

### PNLTm 10 dB DOWN DURATION TIME



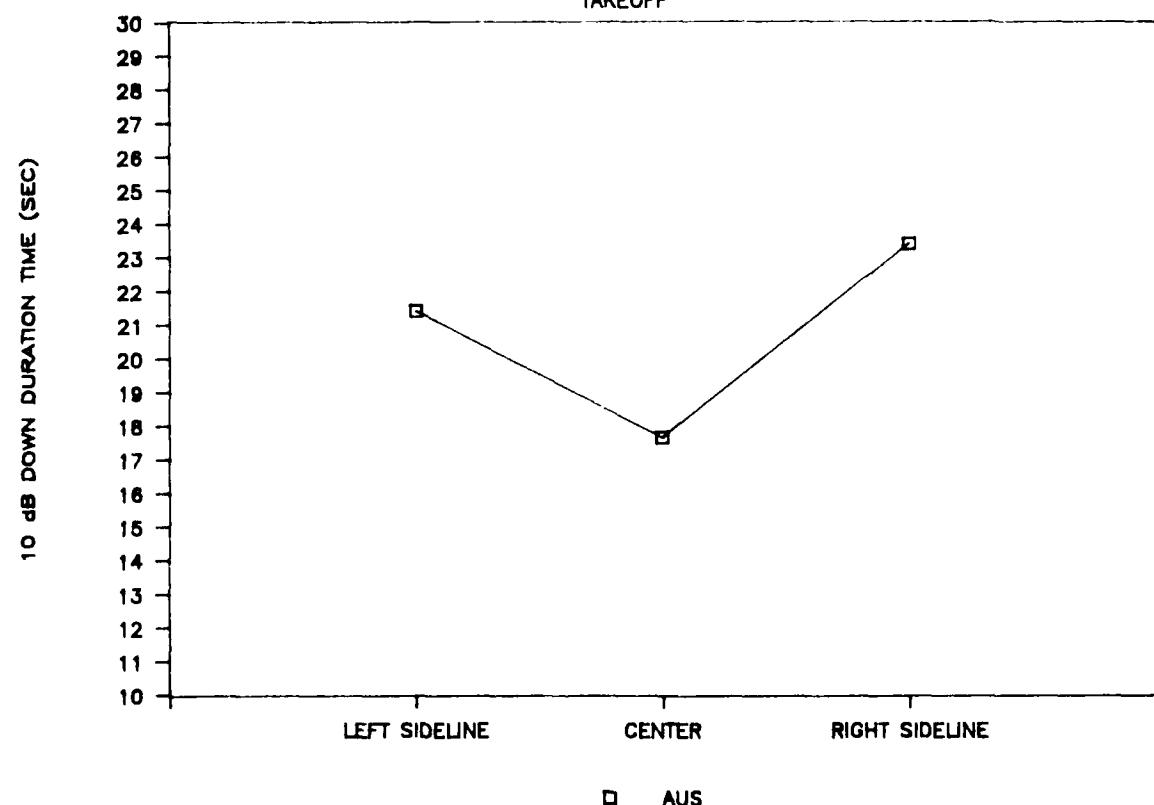
### PNLTm 10 dB DOWN DURATION TIME





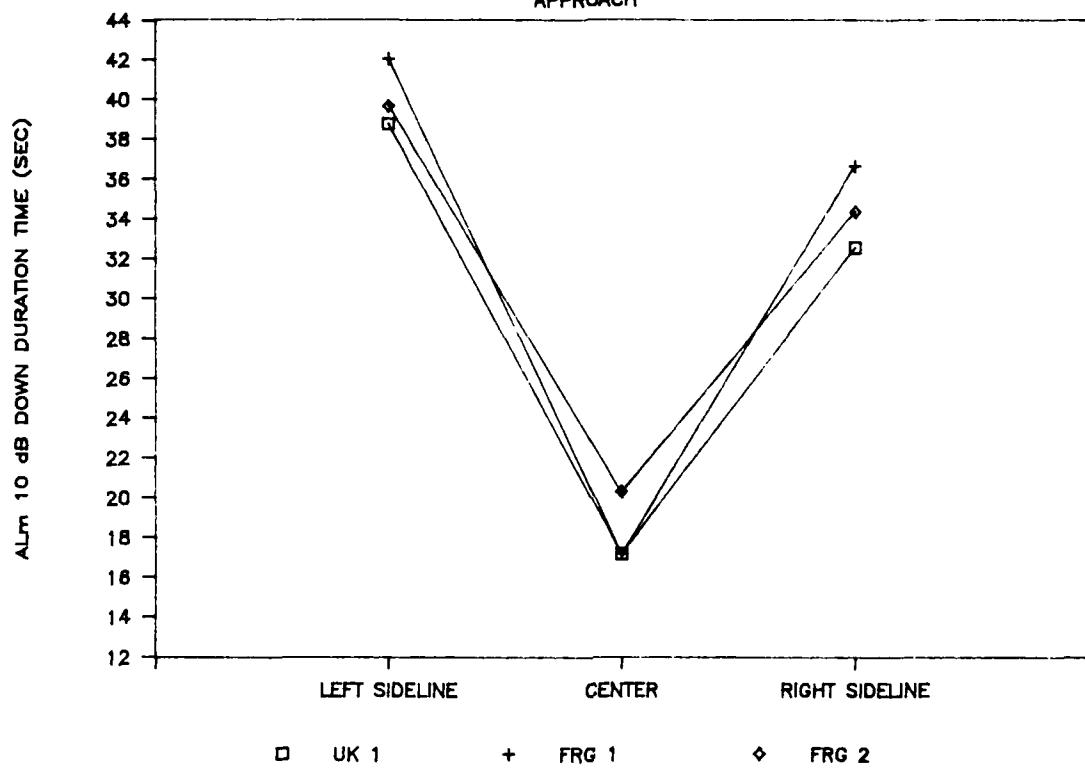
PNLTm 10 dB DOWN DURATION TIME

TAKEOFF



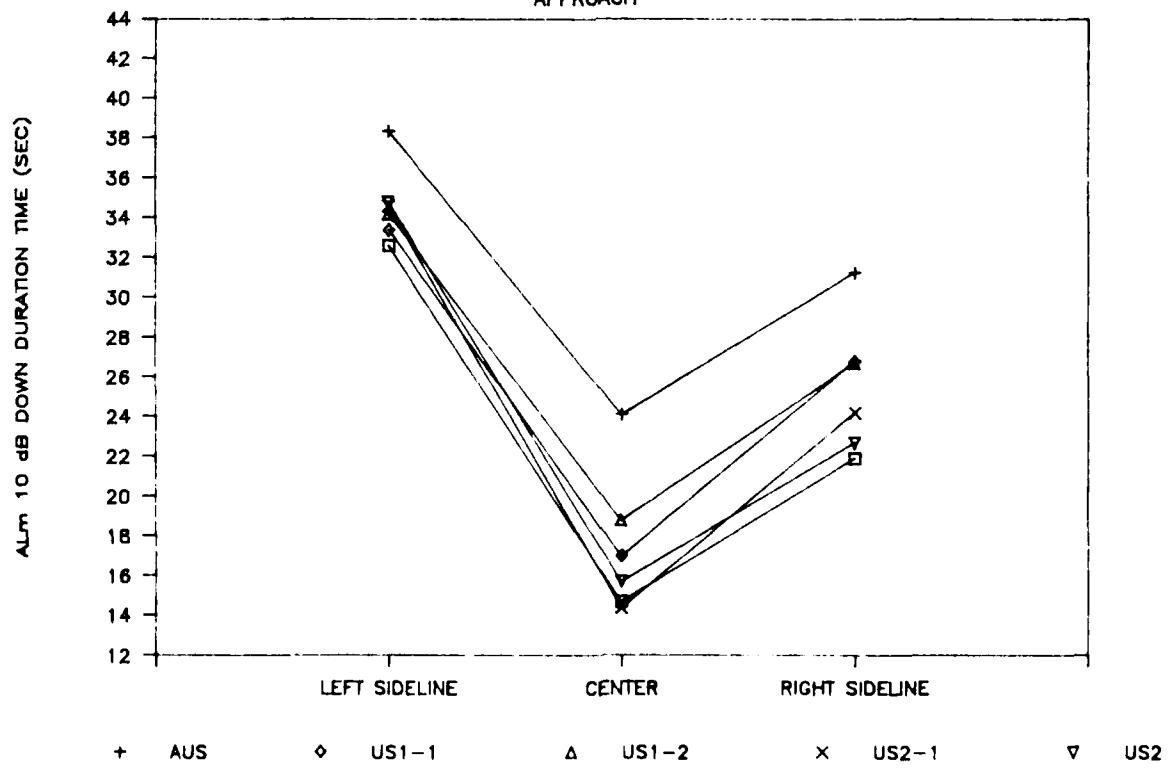
### ALm 10 dB DOWN DURATION TIME

APPROACH



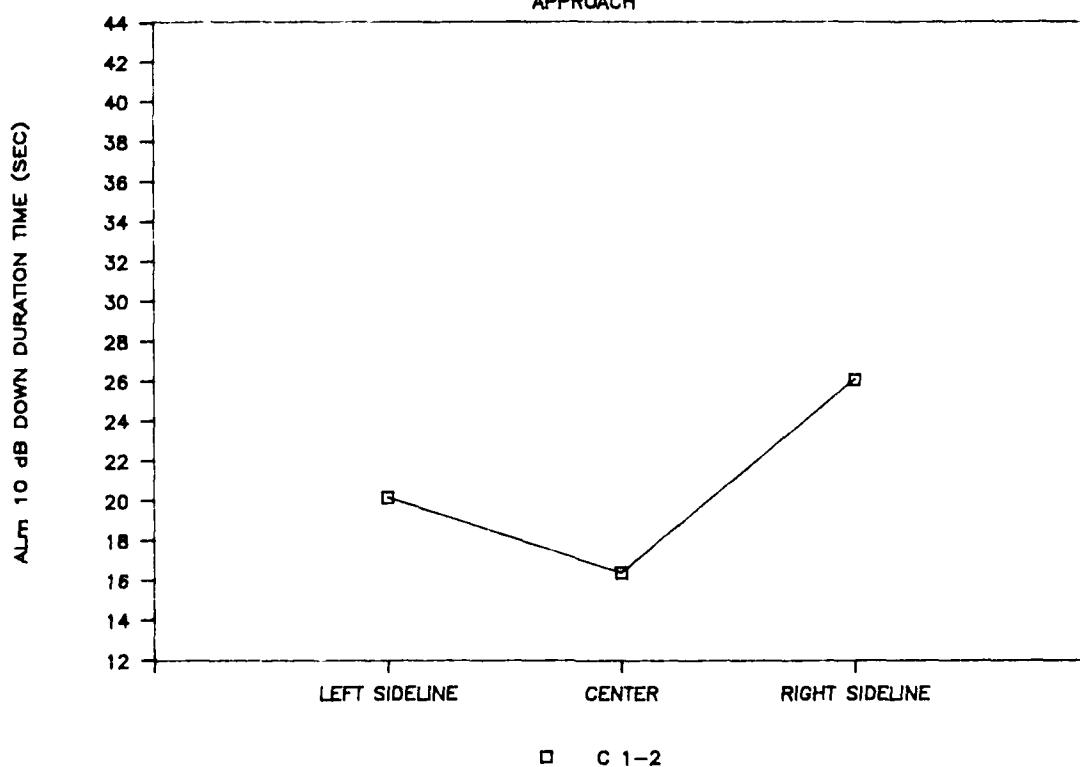
### ALm 10 dB DOWN DURATION TIME

APPROACH



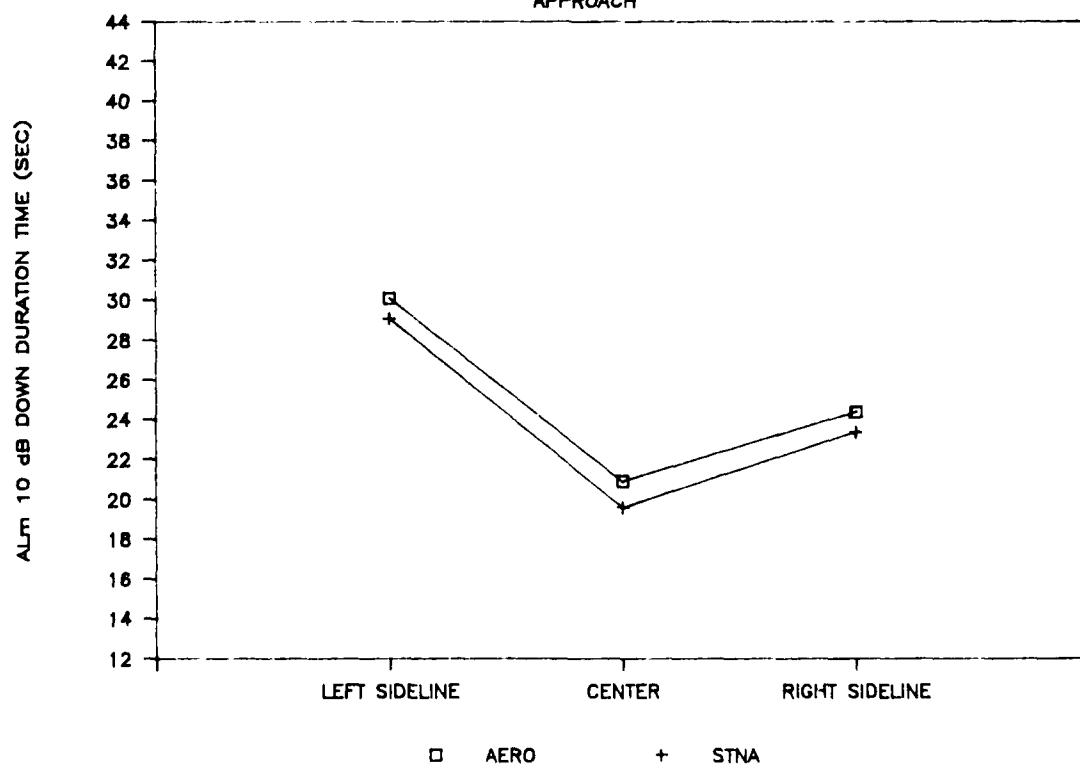
### ALm 10 dB DOWN DURATION TIME

APPROACH



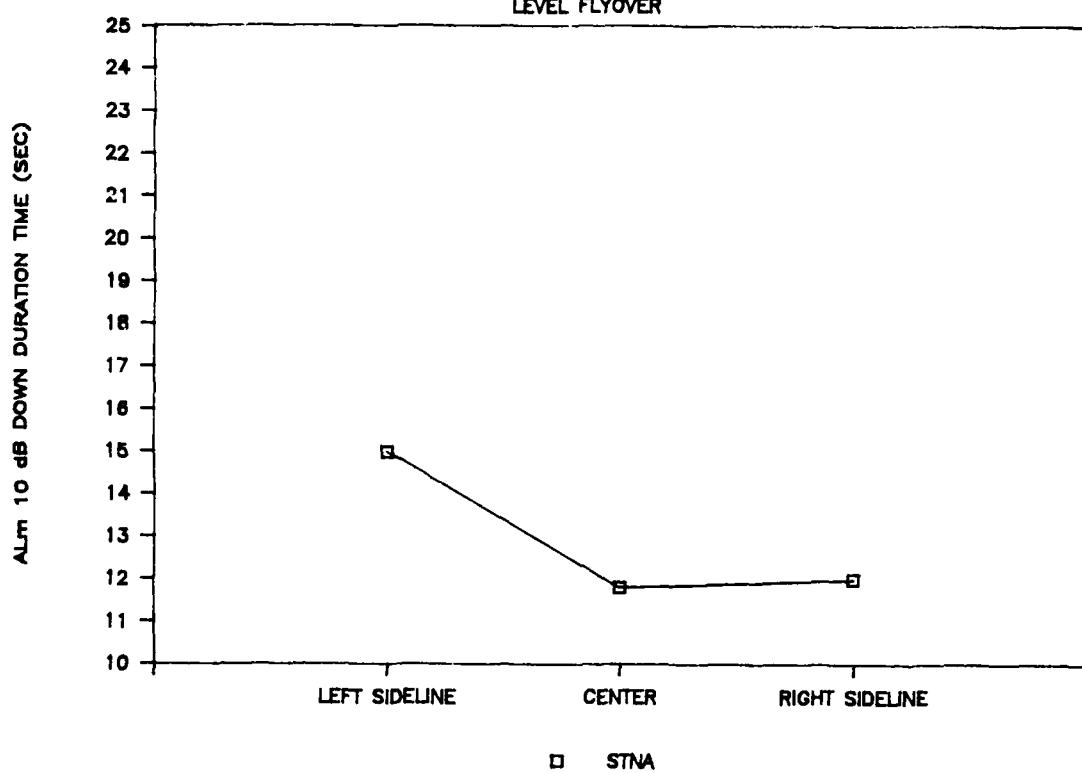
### ALm 10 dB DOWN DURATION TIME

APPROACH



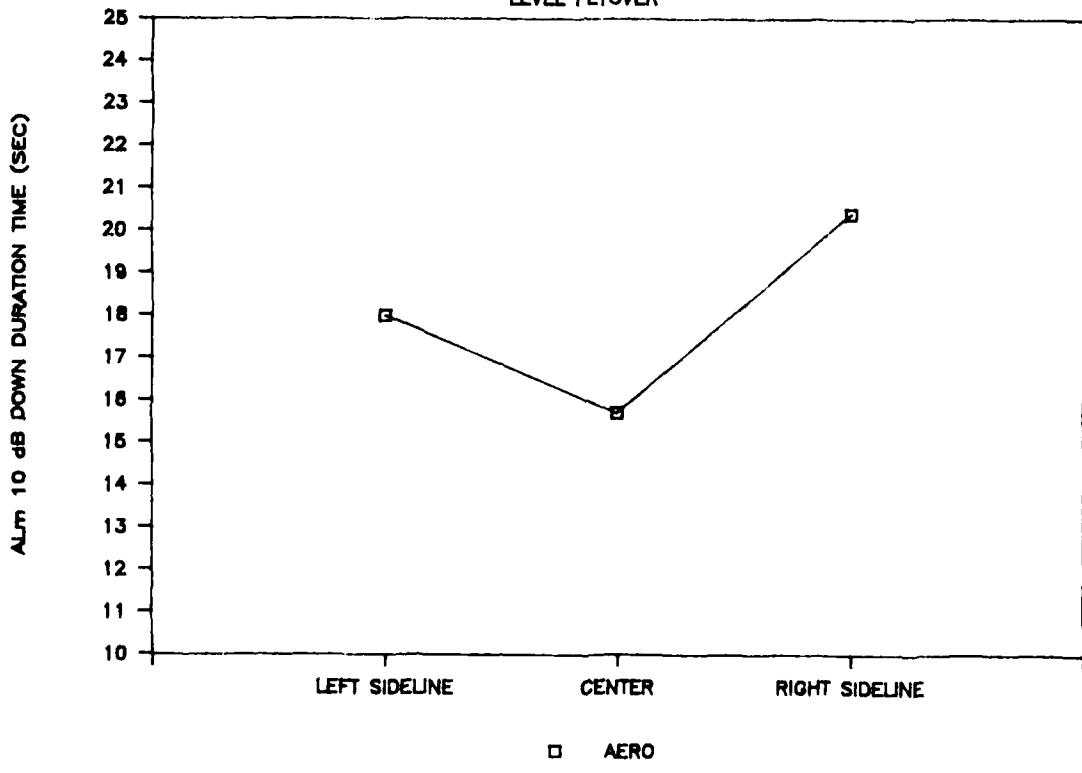
### ALm 10 dB DOWN DURATION TIME

LEVEL FLYOVER



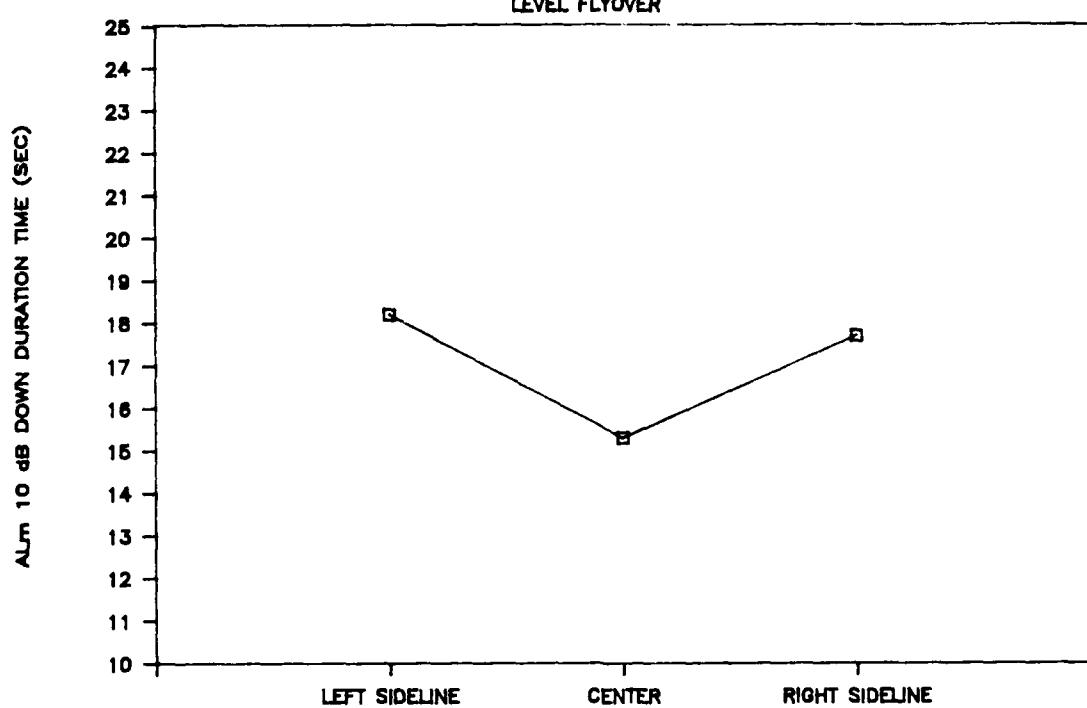
### ALm 10 dB DOWN DURATION TIME

LEVEL FLYOVER



### ALm 10 dB DOWN DURATION TIME

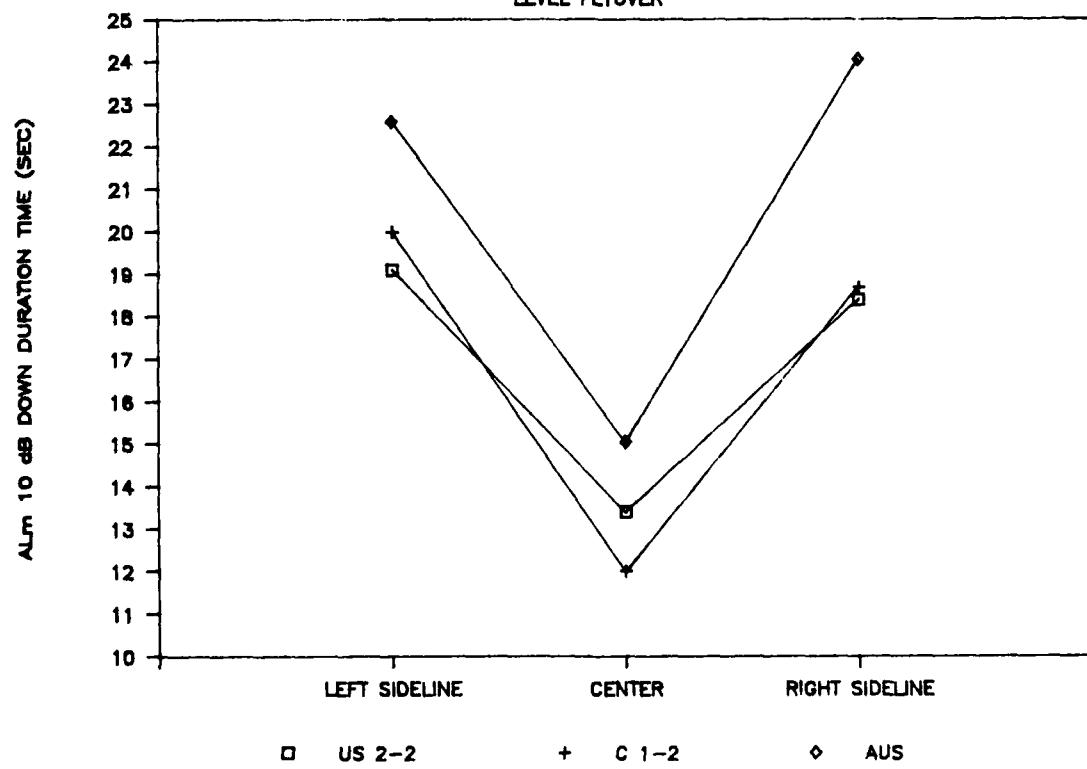
LEVEL FLYOVER



□ FRG 2

### ALm 10 dB DOWN DURATION TIME

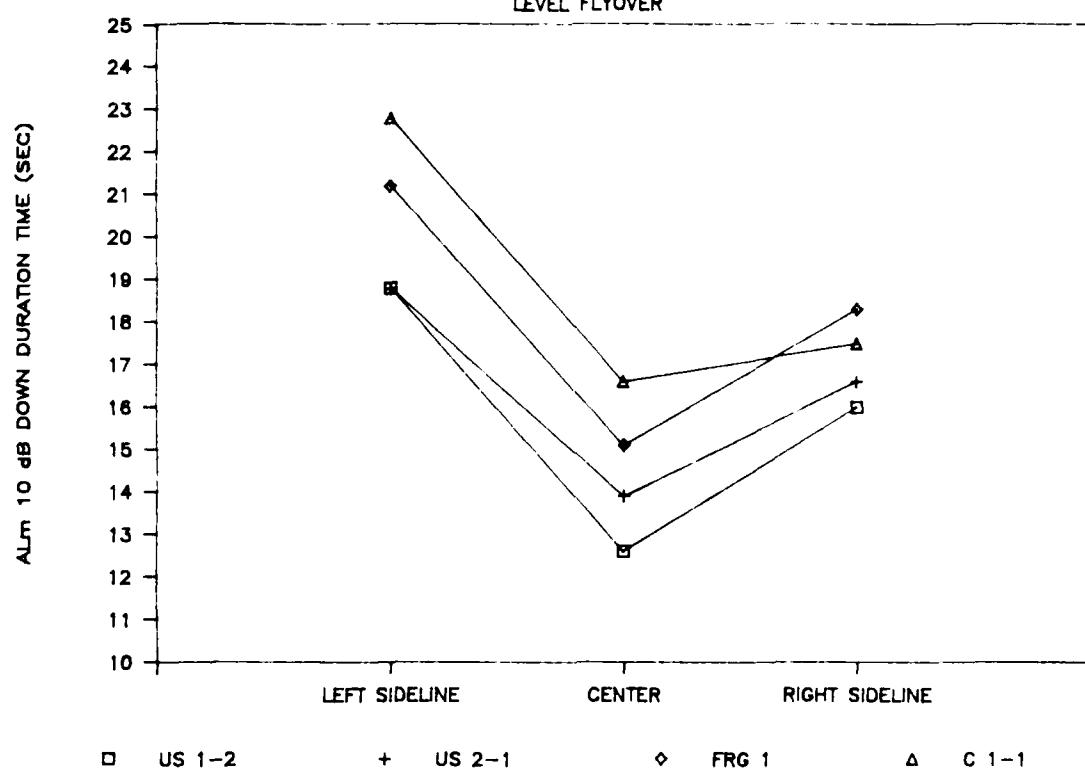
LEVEL FLYOVER



□ US 2-2      + C 1-2      ◆ AUS

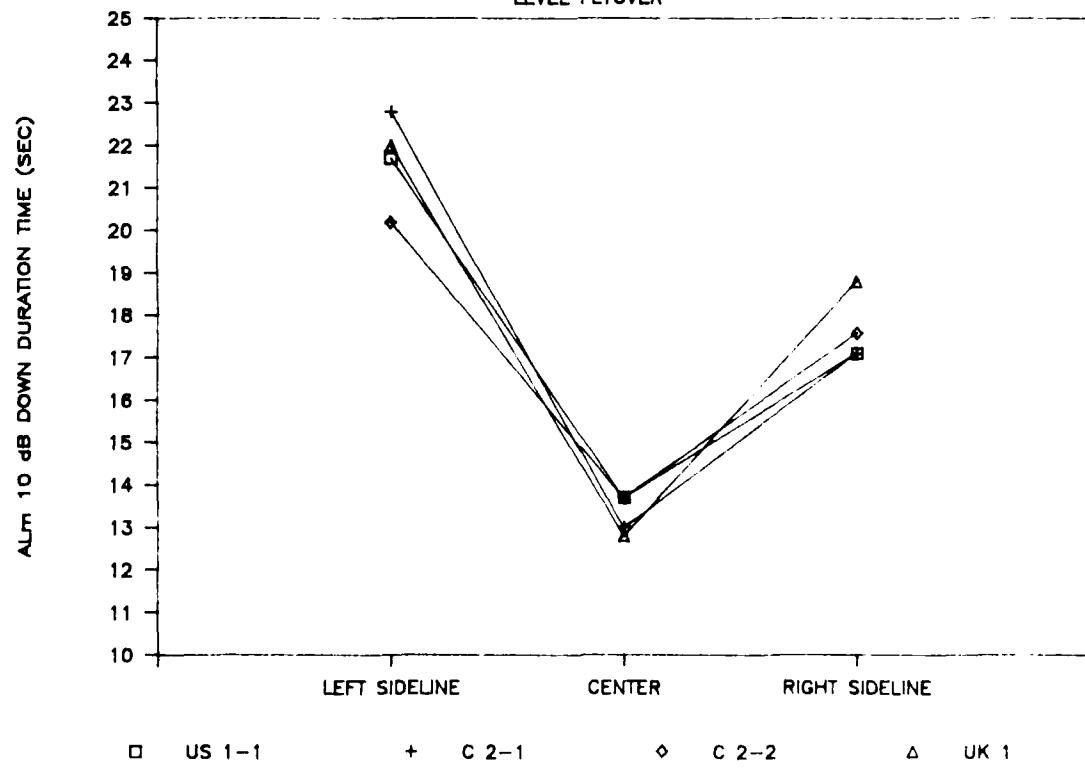
### ALm 10 dB DOWN DURATION TIME

LEVEL FLYOVER

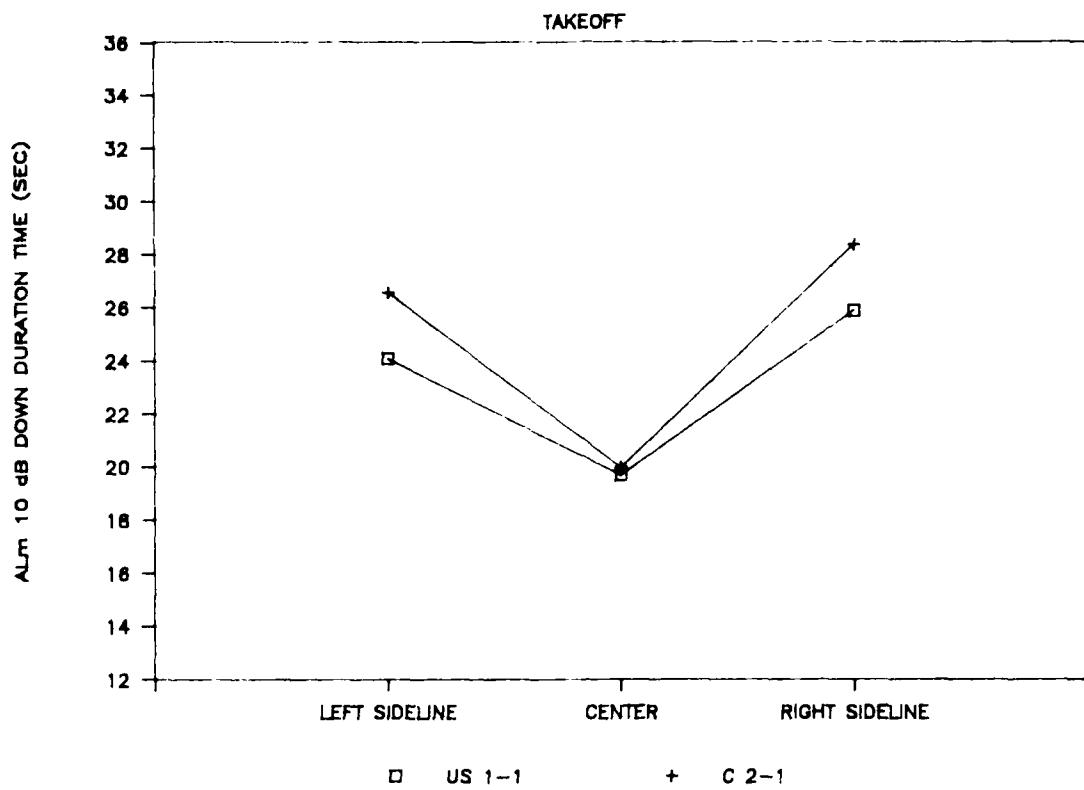


### ALm 10 dB DOWN DURATION TIME

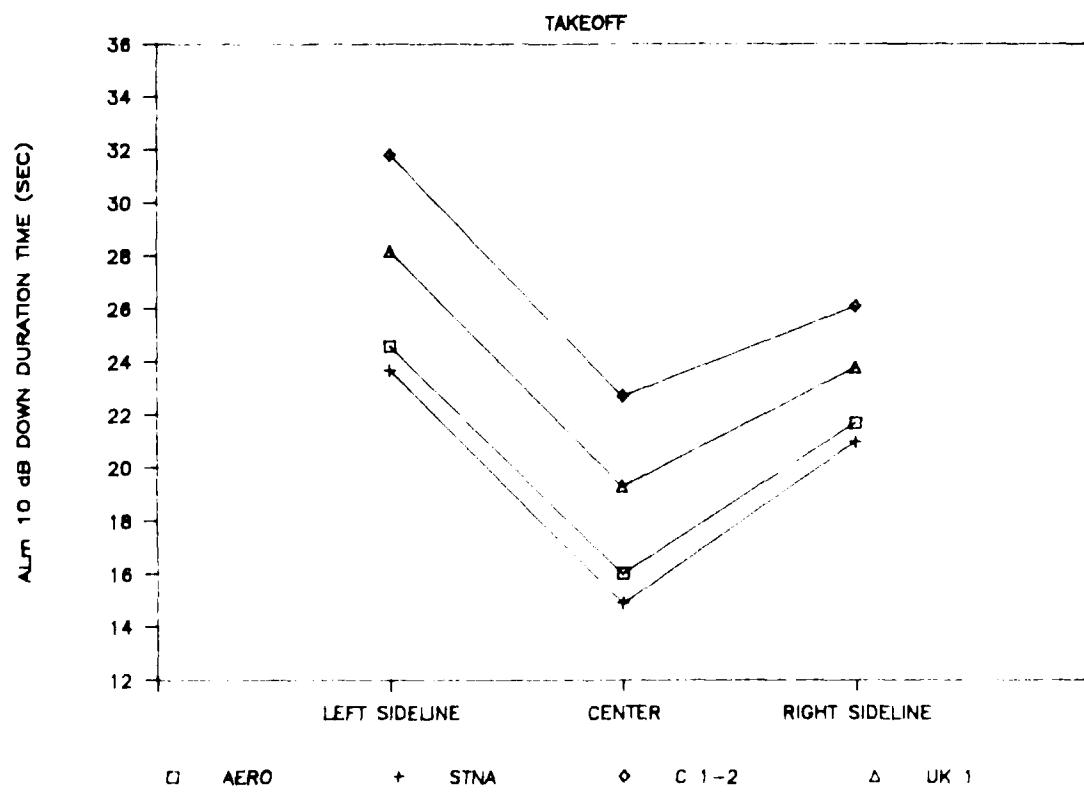
LEVEL FLYOVER



### ALm 10 dB DOWN DURATION TIME

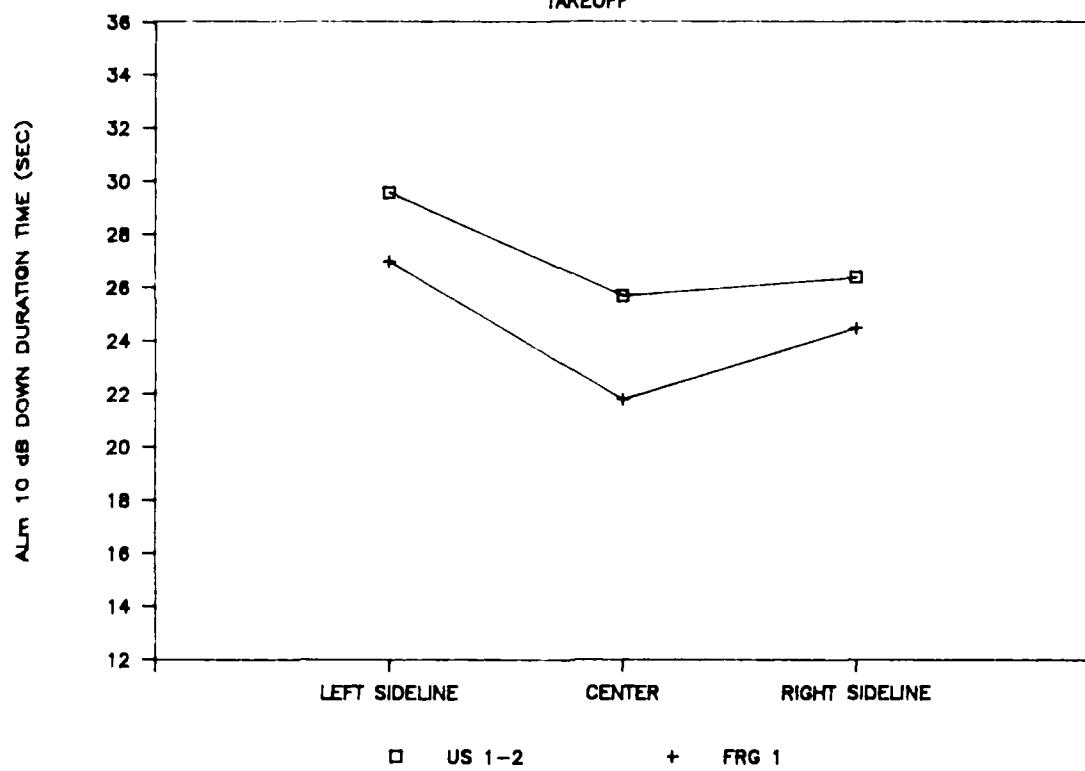


### ALm 10 dB DOWN DURATION TIME



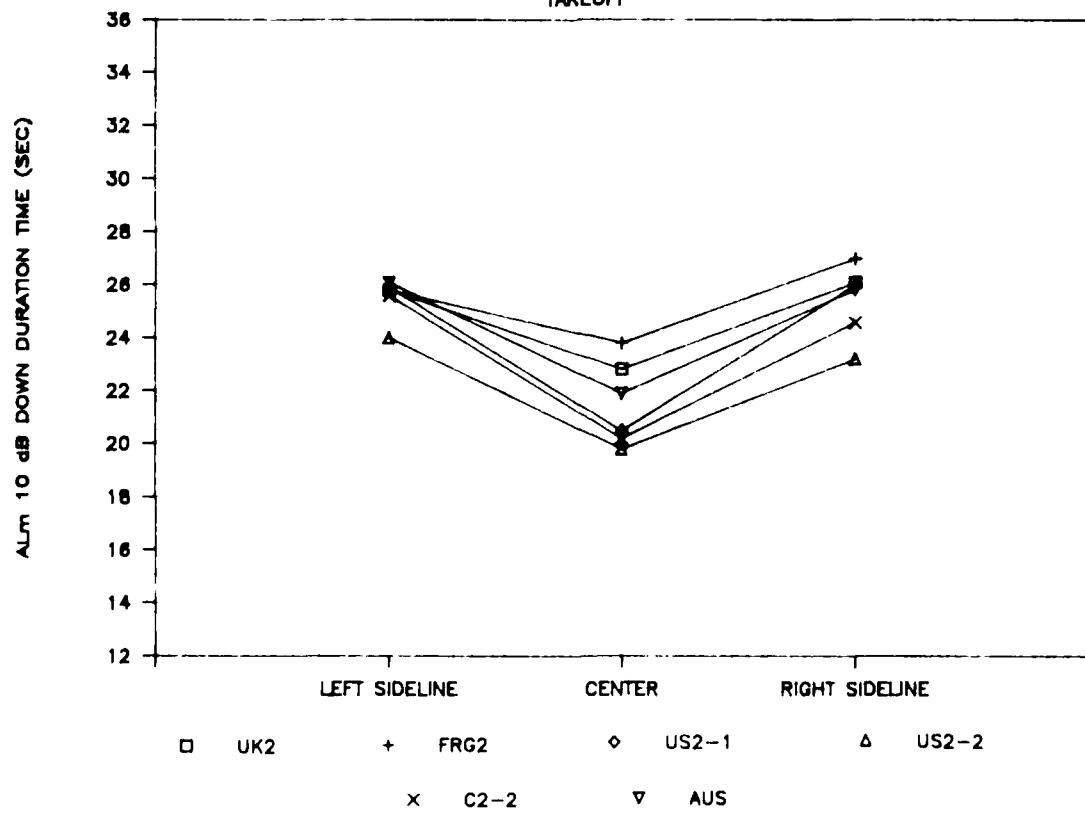
### ALm 10 dB DOWN DURATION TIME

TAKEOFF



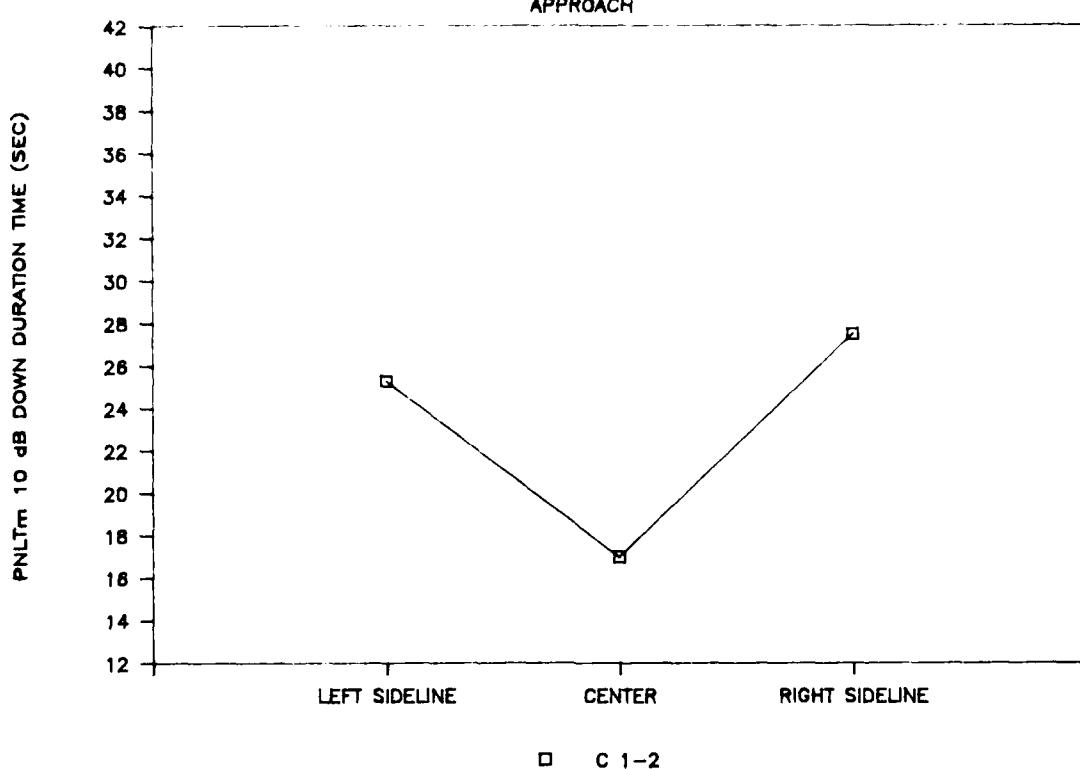
### ALm 10 dB DOWN DURATION TIME

TAKEOFF



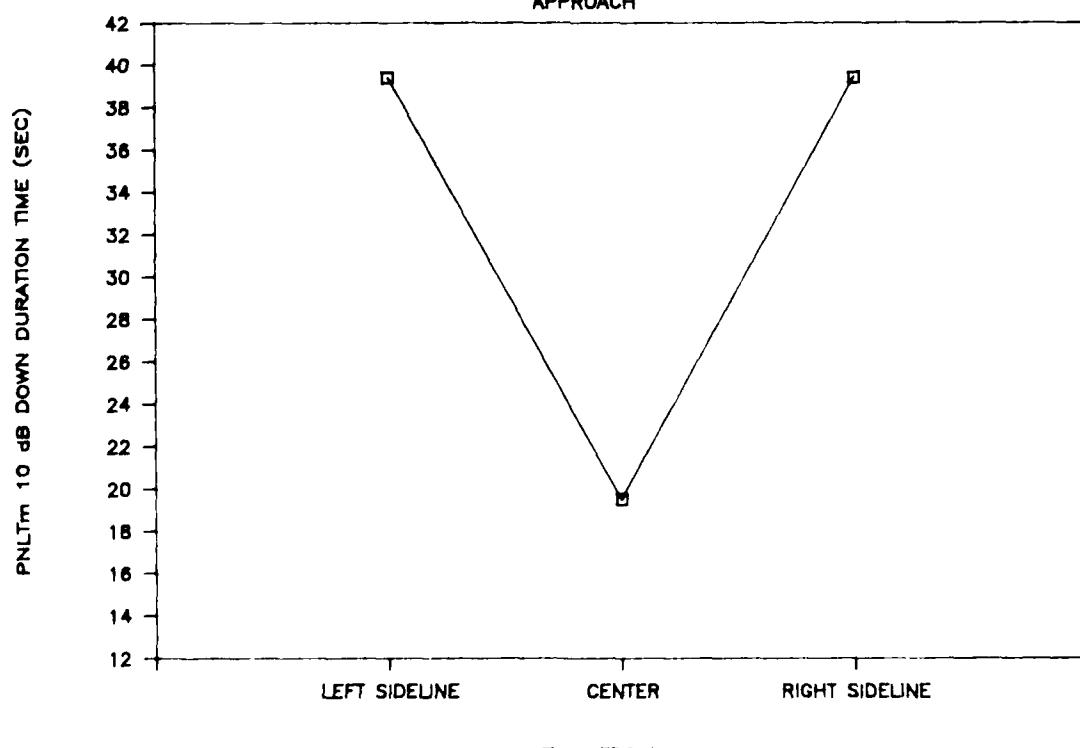
PNLTm 10 dB DOWN DURATION TIME

APPROACH



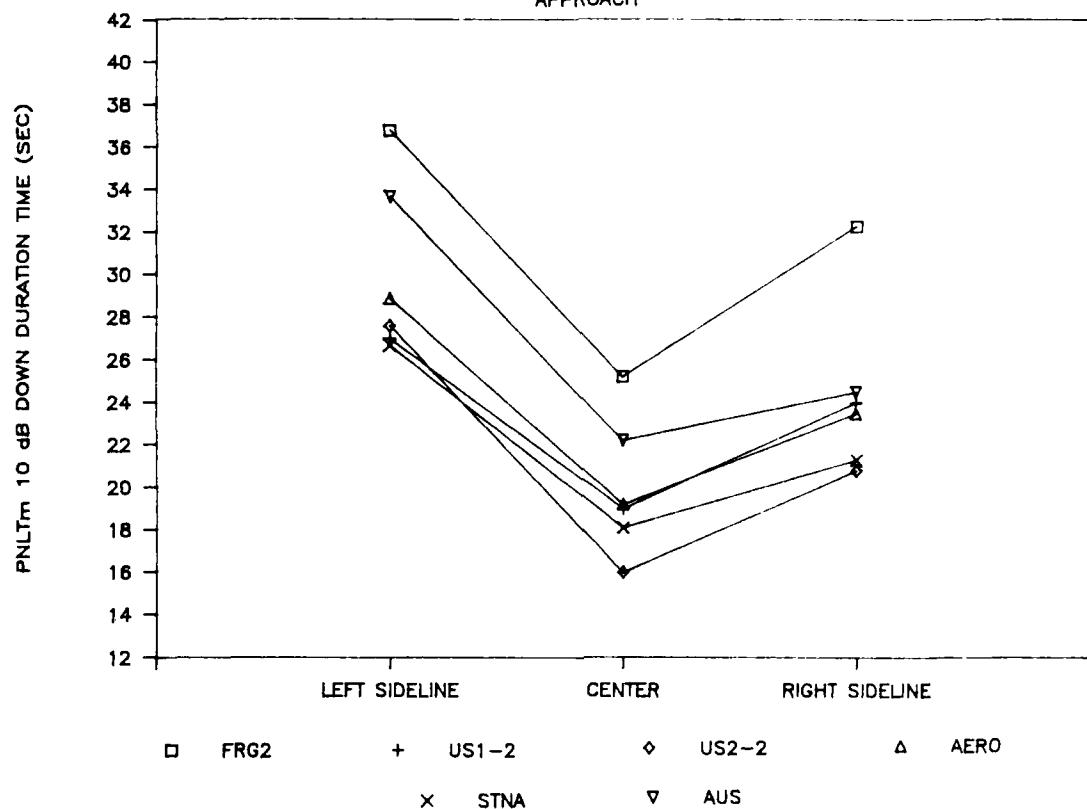
PNLTm 10 dB DOWN DURATION TIME

APPROACH



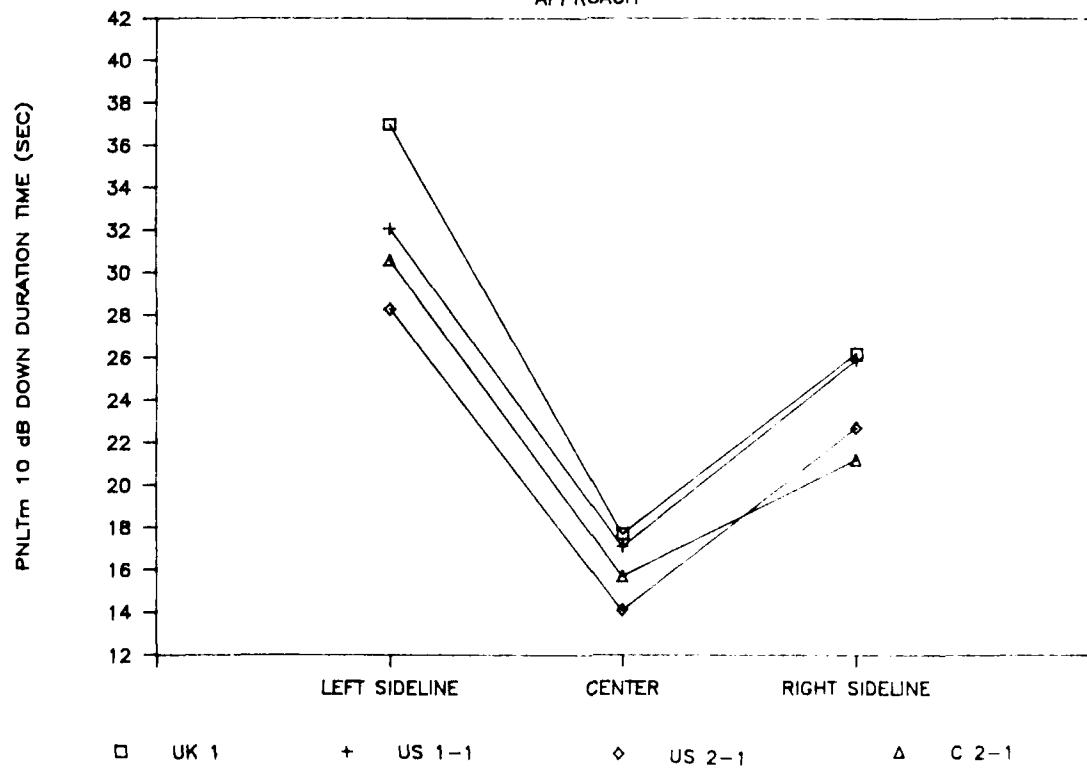
### PNLTm 10 dB DOWN DURATION TIME

APPROACH



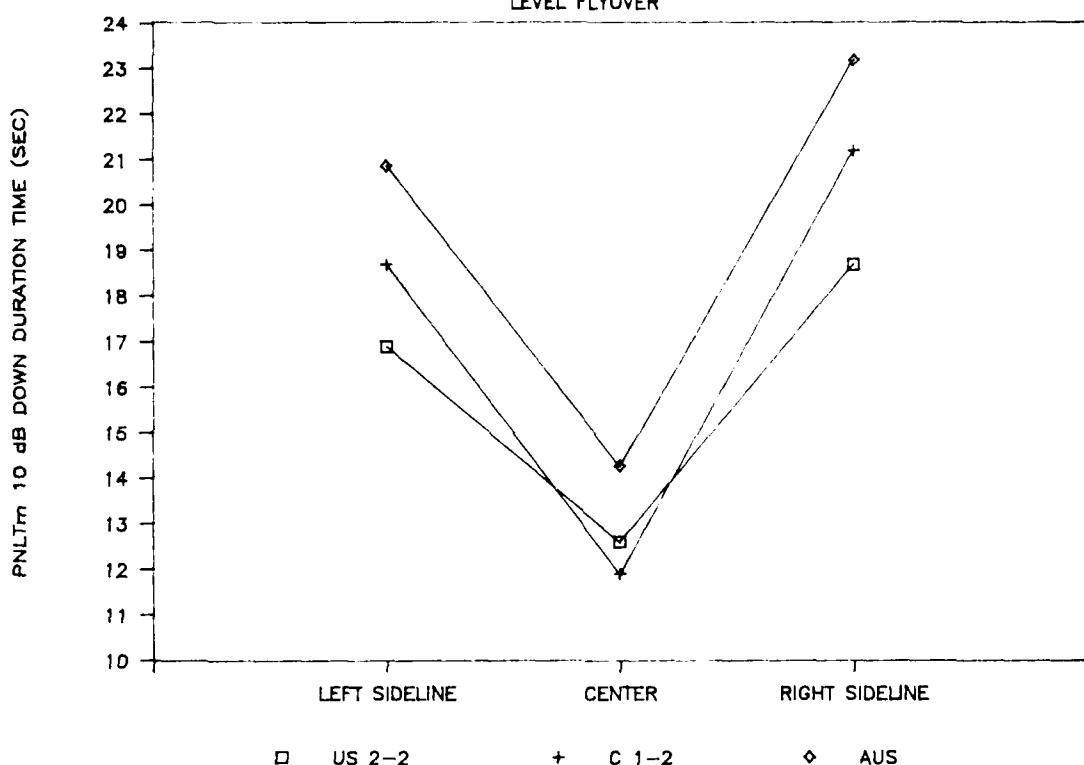
### PNLTm 10 dB DOWN DURATION TIME

APPROACH



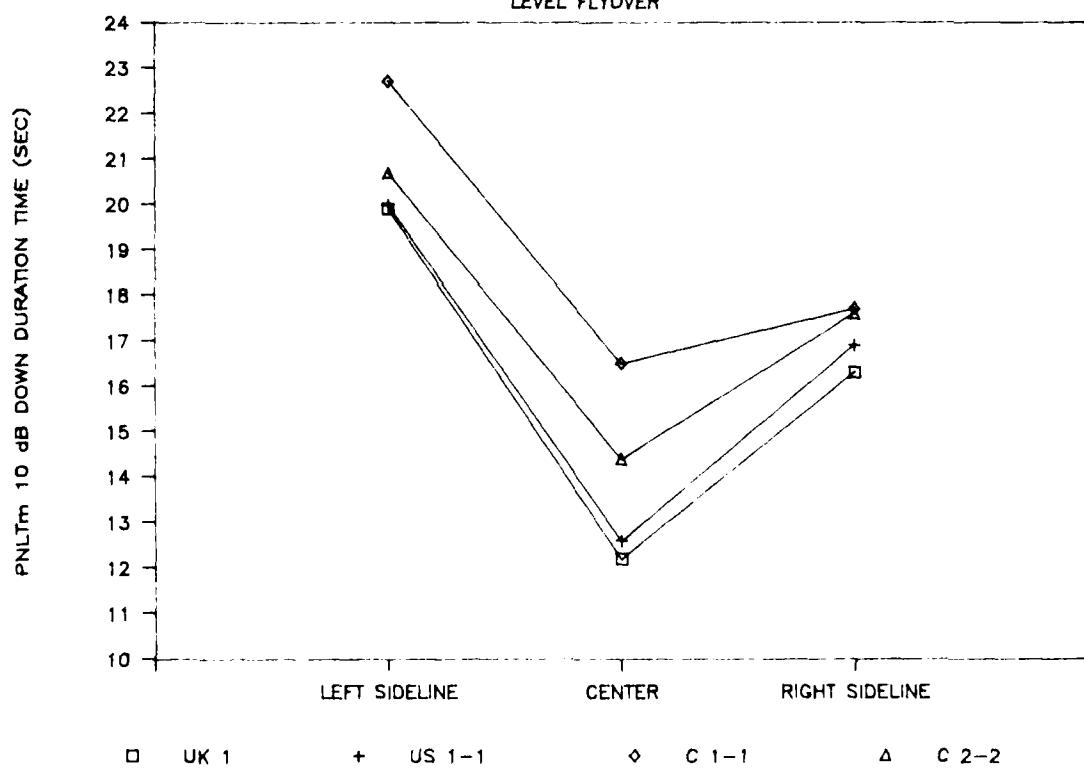
### PNLTm 10 dB DOWN DURATION TIME

LEVEL FLYOVER



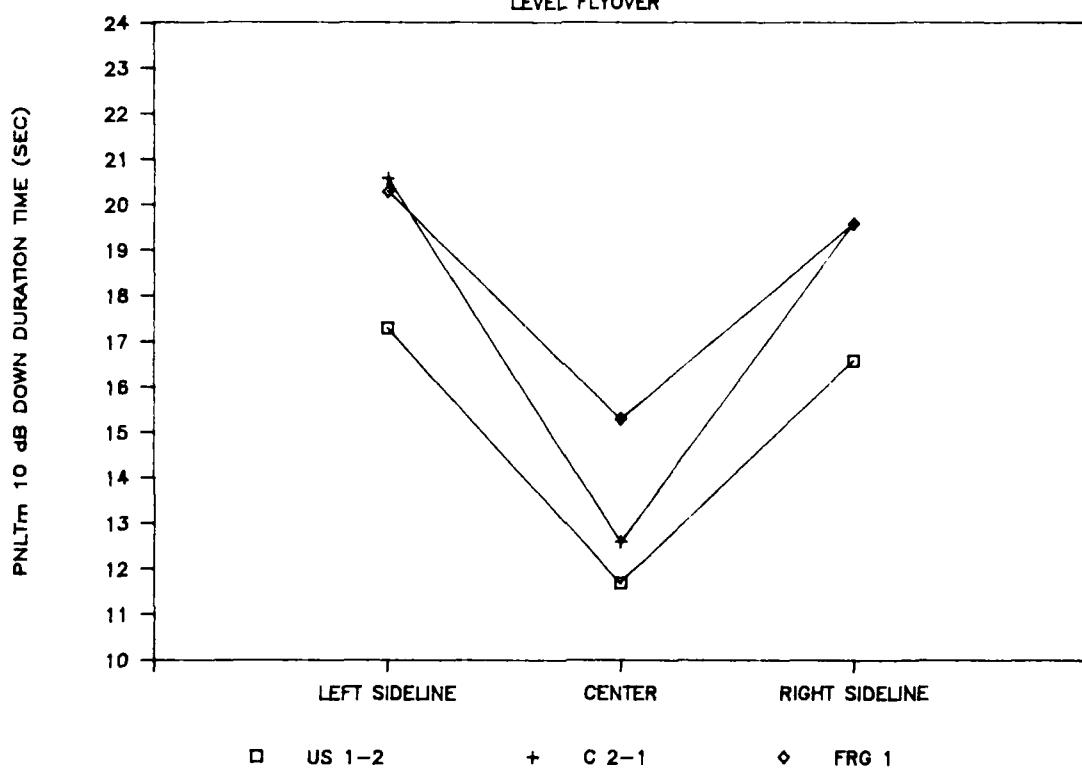
### PNLTm 10 dB DOWN DURATION TIME

LEVEL FLYOVER



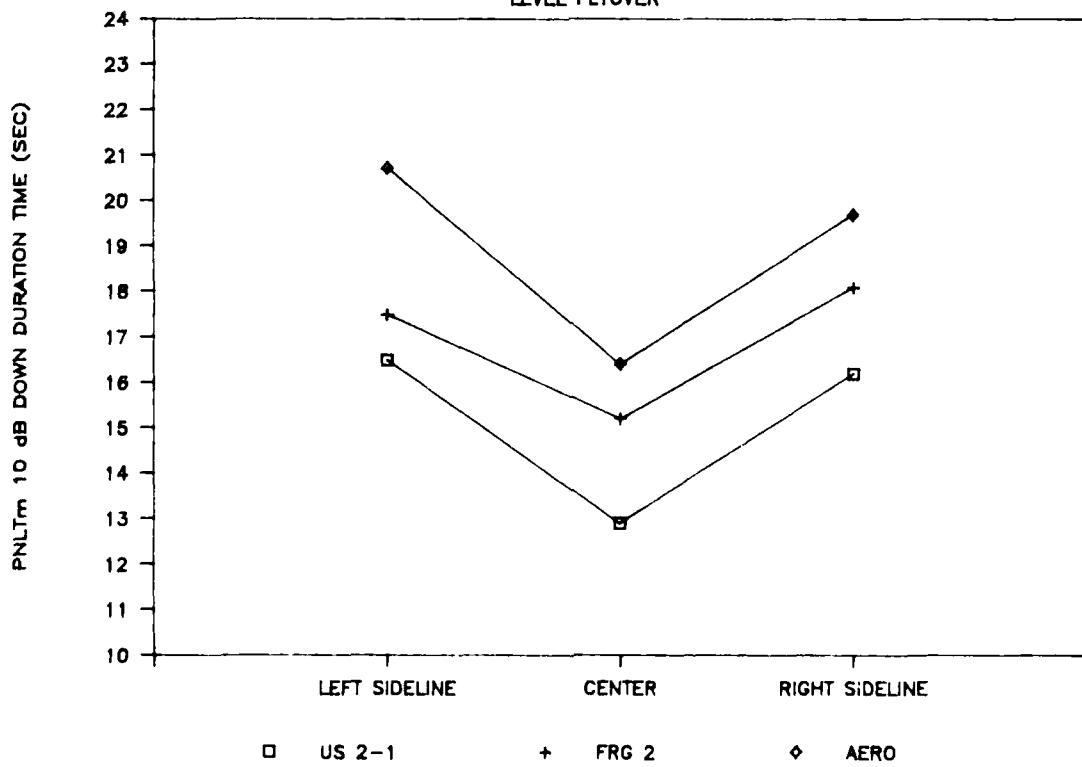
### PNLTm 10 dB DOWN DURATION TIME

LEVEL FLYOVER



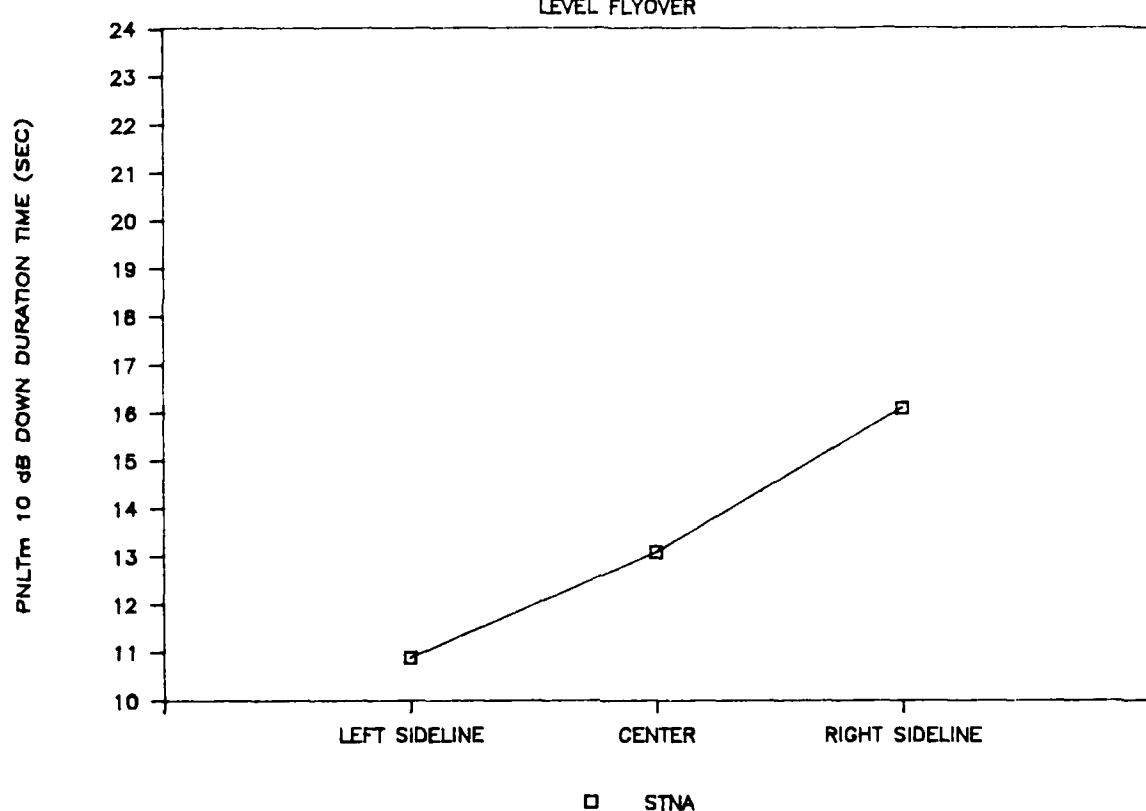
### PNLTm 10 dB DOWN DURATION TIME

LEVEL FLYOVER



PNLTm 10 dB DOWN DURATION TIME

LEVEL FLYOVER



## **Appendix B**

### **Meteorological Data**

# Wind Data

## Australian Test

| OPERATION: APPROACH |       | FLIGHT<br>DIRECTION | WIND<br>SPEED | WIND<br>DIRECTION | CROSS WIND COMPONENT<br>(LEFT/RIGHT) | ON TRACK COMPONENT<br>(HEAD/TAIL) |
|---------------------|-------|---------------------|---------------|-------------------|--------------------------------------|-----------------------------------|
| TIME                | EVENT | (DEGREES)           | (KNOTS)       | (DEGREES)         | DIRECTION (KNOTS)                    | DIRECTION (KNOTS)                 |
| 9.03                | 8     | 180                 | 1.94          | 285               | RIGHT                                | 1.88 TAIL 0.50                    |
| 9.08                | 9     | 180                 | 1.94          | 285               | RIGHT                                | 1.88 TAIL 0.50                    |
| 9.15                | 10    | 180                 | 1.94          | 280               | RIGHT                                | 1.91 TAIL 0.34                    |
| 9.20                | 11    | 180                 | 1.94          | 280               | RIGHT                                | 1.91 TAIL 0.34                    |
| 11.08               | 22    | 180                 | 1.94          | 280               | RIGHT                                | 1.91 TAIL 0.34                    |
| 11.12               | 23    | 180                 | 3.88          | 360               | NO X-WIND                            | 0.00 TAIL 3.89                    |
| 14.18               | 30    | 180                 | 3.88          | 360               | NO X-WIND                            | 0.00 TAIL 3.89                    |
| 15.39               | 37    | 180                 | 5.82          | 020               | LEFT                                 | 1.99 TAIL 5.48                    |
| OPERATION: FLYOVER  |       | FLIGHT<br>DIRECTION | WIND<br>SPEED | WIND<br>DIRECTION | CROSS WIND COMPONENT<br>(LEFT/RIGHT) | ON TRACK COMPONENT<br>(HEAD/TAIL) |
| TIME                | EVENT | (DEGREES)           | (KNOTS)       | (DEGREES)         | DIRECTION (KNOTS)                    | DIRECTION (KNOTS)                 |
| 8.25                | 1     | 360                 | 1.94          | 295               | LEFT                                 | 1.76 HEAD 0.82                    |
| 8.28                | 2     | 180                 | 1.94          | 295               | RIGHT                                | 1.76 TAIL 0.82                    |
| 8.32                | 3     | 360                 | 1.94          | 295               | LEFT                                 | 1.76 HEAD 0.82                    |
| 8.35                | 4     | 180                 | 1.94          | 295               | RIGHT                                | 1.76 TAIL 0.82                    |
| 8.39                | 5     | 360                 | 1.94          | 295               | LEFT                                 | 1.76 HEAD 0.82                    |
| 8.42                | 6     | 180                 | 1.94          | 295               | RIGHT                                | 1.76 TAIL 0.82                    |
| 8.45                | 7     | 360                 | 1.94          | 300               | LEFT                                 | 1.68 HEAD 0.97                    |
| 14.50               | 31    | 180                 | 3.88          | 020               | LEFT                                 | 1.33 TAIL 3.65                    |
| 14.53               | 31    | 360                 | 3.88          | 020               | RIGHT                                | 1.33 HEAD 3.65                    |
| 14.56               | 33    | 180                 | 3.88          | 020               | LEFT                                 | 1.33 TAIL 3.65                    |
| 14.58               | 34    | 360                 | 3.88          | 340               | LEFT                                 | 1.33 HEAD 3.65                    |
| 15.32               | 35    | 180                 | 3.88          | 020               | LEFT                                 | 1.33 TAIL 3.65                    |
| 15.35               | 36    | 360                 | 5.82          | 020               | RIGHT                                | 1.99 HEAD 5.48                    |
| OPERATION: TAKEOFF  |       | FLIGHT<br>DIRECTION | WIND<br>SPEED | WIND<br>DIRECTION | CROSS WIND COMPONENT<br>(LEFT/RIGHT) | ON TRACK COMPONENT<br>(HEAD/TAIL) |
| TIME                | EVENT | (DEGREES)           | (KNOTS)       | (DEGREES)         | DIRECTION (KNOTS)                    | DIRECTION (KNOTS)                 |
| 10.21               | 12    | 180                 | 3.88          | 315               | RIGHT                                | 2.03 TAIL 3.16                    |
| 10.24               | 13    | 180                 | 3.88          | 315               | RIGHT                                | 2.03 TAIL 3.16                    |
| 10.28               | 14    | 180                 | 3.88          | 325               | RIGHT                                | 2.03 TAIL 3.16                    |
| 10.31               | 15    | 180                 | 3.88          | 325               | RIGHT                                | 2.03 TAIL 3.16                    |
| 10.34               | 16    | 180                 | 3.88          | 330               | RIGHT                                | 1.94 TAIL 3.37                    |
| 10.36               | 17    | 180                 | 3.88          | 330               | RIGHT                                | 1.94 TAIL 3.37                    |
| 10.39               | 18    | 180                 | 3.88          | 330               | RIGHT                                | 1.94 TAIL 3.37                    |
| 10.42               | 19    | 180                 | 3.88          | 330               | RIGHT                                | 1.94 TAIL 3.37                    |
| 10.45               | 20    | 180                 | 3.88          | 360               | NO X-WIND                            | 0.00 TAIL 3.89                    |
| 11.04               | 21    | 180                 | 3.88          | 360               | NO X-WIND                            | 0.00 TAIL 3.89                    |
| 14.06               | 24    | 180                 | 3.88          | 005               | LEFT                                 | 1.34 TAIL 3.87                    |
| 14.07               | 25    | 180                 | 3.88          | 005               | LEFT                                 | 1.34 TAIL 3.87                    |
| 14.07               | 26    | 180                 | 3.88          | 005               | LEFT                                 | 1.34 TAIL 3.87                    |
| 14.11               | 27    | 180                 | 3.88          | 005               | NO X-WIND                            | 0.00 TAIL 3.89                    |
| 14.12               | 28    | 180                 | 3.88          | 005               | NO X-WIND                            | 0.00 TAIL 3.89                    |
| 14.16               | 29    | 180                 | 3.88          | 005               | NO X-WIND                            | 0.00 TAIL 3.89                    |

# Wind Data

## French-Italian Test

| OPERATION: APPROACH |       | FLIGHT<br>TIME | WIND<br>DIRECTION<br>(DEGREES) | WIND<br>SPEED<br>(KNOTS) | WIND<br>DIRECTION<br>(DEGREES) | CROSS WIND COMPONENT<br>(LEFT/RIGHT)<br>DIRECTION<br>(KNOTS) | ON TRACK COMPONENT<br>(HEAD/TAIL)<br>DIRECTION<br>(KNOTS) |
|---------------------|-------|----------------|--------------------------------|--------------------------|--------------------------------|--|---|
| TIME                | EVENT |                |                                |                          |                                |  |   |
| 16.00               | 98    | 089            | 6.0                            | 180                      | RIGHT                          | 6.00   | TAIL  |
| 16.04               | 99    | 089            | 6.5                            | 180                      | RIGHT                          | 6.15   | HEAD  |
| 16.08               | 100   | 089            | 6.0                            | 180                      | RIGHT                          | 5.67   | HEAD  |
| 16.11               | 101   | 089            | 11.0                           | 130                      | RIGHT                          | 11.00  | TAIL  |
| 16.18               | 103   | 089            | 5.5                            | 180                      | RIGHT                          | 5.20   | HEAD  |
| 16.25               | 104   | 089            | 6.0                            | 180                      | RIGHT                          | 6.00   | TAIL  |
| 16.28               | 105   | 089            | 4.0                            | 140                      | RIGHT                          | 3.11   | HEAD  |

| OPERATION: FLYOVER |       | FLIGHT<br>TIME | WIND<br>DIRECTION<br>(DEGREES) | WIND<br>SPEED<br>(KNOTS) | WIND<br>DIRECTION<br>(DEGREES) | CROSS WIND COMPONENT<br>(LEFT/RIGHT)<br>DIRECTION<br>(KNOTS) | ON TRACK COMPONENT<br>(HEAD/TAIL)<br>DIRECTION<br>(KNOTS) |
|--------------------|-------|----------------|--------------------------------|--------------------------|--------------------------------|--|---|
| TIME               | EVENT |                |                                |                          |                                |  |   |
| 11.42              | 5     | 269            | 1.0                            | 255                      | LEFT                           | 0.24   | HEAD  |
| 11.45              | 6     | 089            | 0.0                            | 260                      | NO X-WIND                      | 0.00   | NO H/T WIND   |
| 11.47              | 7     | 269            | 1.0                            | 272                      | RIGHT                          | 0.05   | HEAD  |
| 11.50              | 8     | 089            | 1.0                            | 280                      | LEFT                           | 0.19   | TAIL  |
| 11.55              | 9     | 269            | 1.0                            | 300                      | RIGHT                          | 0.32   | HEAD  |
| 11.59              | 10    | 089            | 1.0                            | 280                      | LEFT                           | 0.19   | TAIL  |
| 12.02              | 11    | 269            | 1.0                            | 280                      | RIGHT                          | 0.19   | HEAD  |
| 12.04              | 12    | 089            | 1.0                            | 280                      | LEFT                           | 0.19   | TAIL  |
| 12.09              | 13    | 089            | NA                             | NA                       | NO X-WIND                      | NA   | NO H/T WIND   |
| 12.12              | 14    | 269            | NA                             | NA                       | NO X-WIND                      | NA   | NO H/T WIND   |

| OPERATION: TAKEOFF |       | FLIGHT<br>TIME | WIND<br>DIRECTION<br>(DEGREES) | WIND<br>SPEED<br>(KNOTS) | WIND<br>DIRECTION<br>(DEGREES) | CROSS WIND COMPONENT<br>(LEFT/RIGHT)<br>DIRECTION<br>(KNOTS) | ON TRACK COMPONENT<br>(HEAD/TAIL)<br>DIRECTION<br>(KNOTS) |
|--------------------|-------|----------------|--------------------------------|--------------------------|--------------------------------|--|---|
| TIME               | EVENT |                |                                |                          |                                |  |   |
| 12.21              | 88    | 089            | 7.0                            | 220                      | RIGHT                          | 5.18   | TAIL  |
| 12.23              | 89    | 089            | 7.0                            | 220                      | RIGHT                          | 5.28   | TAIL  |
| 12.26              | 90    | 089            | 4.0                            | 220                      | RIGHT                          | 3.32   | TAIL  |
| 12.29              | 91    | 089            | 7.0                            | 220                      | RIGHT                          | 5.28   | TAIL  |
| 12.32              | 92    | 089            | 7.0                            | 220                      | RIGHT                          | 5.18   | TAIL  |
| 12.34              | 93    | 089            | 6.0                            | 240                      | RIGHT                          | 2.91   | TAIL  |
| 12.37              | 94    | 089            | 3.0                            | 220                      | RIGHT                          | 2.26   | TAIL  |

# Wind Data

## Japanese Test

| OPERATION: APPROACH |         | FLIGHT                 | WIND             | WIND                   | CROSS WIND COMPONENT                 | ON TRACK COMPONENT                  |
|---------------------|---------|------------------------|------------------|------------------------|--------------------------------------|-------------------------------------|
| TIME                | EVENT   | DIRECTION<br>(DEGREES) | SPEED<br>(KNOTS) | DIRECTION<br>(DEGREES) | (LEFT/RIGHT)<br>DIRECTION<br>(KNOTS) | (HEAD/TAIL)<br>DIRECTION<br>(KNOTS) |
| 14.10               | B1-B    | 190                    | 2.7              | 270                    | RIGHT                                | 2.68                                |
| 14.21               | B1-12   | 190                    | 2.7              | 315                    | RIGHT                                | 2.21                                |
| 14.31               | B1-16   | 190                    | 4.7              | 190                    | NO X-WIND                            | 0.00                                |
| 9.23                | B1-36   | 190                    | 3.1              | 248                    | RIGHT                                | 2.63                                |
| 9.37                | B1-40   | 190                    | 3.3              | 113                    | LEFT                                 | 3.22                                |
| 9.48                | B1-44   | 190                    | 4.3              | 135                    | LEFT                                 | 3.52                                |
| 10.21               | B1-48   | 190                    | 6.4              | 135                    | LEFT                                 | 5.24                                |
| 10.30               | B1-52   | 190                    | 5.2              | 135                    | LEFT                                 | 4.26                                |
| 10.40               | B1-56   | 190                    | 4.3              | 113                    | LEFT                                 | 4.19                                |
| 14.44               | B2-20   | 190                    | 5.8              | 338                    | RIGHT                                | 3.07                                |
| 14.48               | B2-20-1 | 190                    | 4.9              | 315                    | RIGHT                                | 4.01                                |
| 15.18               | B2-24   | 190                    | 1.9              | 090                    | LEFT                                 | 1.87                                |
| 15.29               | B2-28   | 190                    | 2.1              | 113                    | LEFT                                 | 2.05                                |
| 15.40               | B2-32   | 190                    | 1.9              | 090                    | LEFT                                 | 1.87                                |
| 11.18               | B2-60   | 190                    | 6.6              | 135                    | LEFT                                 | 5.41                                |
| 11.11               | B2-64   | 190                    | 8.6              | 158                    | LEFT                                 | 4.56                                |
| 11.39               | B2-68   | 190                    | 3.9              | 113                    | LEFT                                 | 3.80                                |
| 12.07               | B2-72   | 190                    | 6.6              | 158                    | LEFT                                 | 3.50                                |
| 12.17               | B2-76   | 190                    | 6.2              | 180                    | LEFT                                 | 1.08                                |
| 12.28               | B2-80   | 190                    | 8.2              | 158                    | LEFT                                 | 4.35                                |

| OPERATION: FLYOVER |         | FLIGHT                 | WIND             | WIND                   | CROSS WIND COMPONENT                 | ON TRACK COMPONENT                  |
|--------------------|---------|------------------------|------------------|------------------------|--------------------------------------|-------------------------------------|
| TIME               | EVENT   | DIRECTION<br>(DEGREES) | SPEED<br>(KNOTS) | DIRECTION<br>(DEGREES) | (LEFT/RIGHT)<br>DIRECTION<br>(KNOTS) | (HEAD/TAIL)<br>DIRECTION<br>(KNOTS) |
| 9.17               | C1-35   | 010                    | 2.3              | 248                    | LEFT                                 | 1.95                                |
| 9.21               | C1-35-1 | 010                    | 2.5              | 248                    | LEFT                                 | 2.12                                |
| 9.30               | C1-39   | 010                    | 2.3              | 203                    | LEFT                                 | 0.52                                |
| 9.34               | C1-39-1 | 010                    | 1.9              | 180                    | RIGHT                                | 0.33                                |
| 11.16              | C2-59   | 010                    | 6.2              | 135                    | RIGHT                                | 5.08                                |
| 11.25              | C2-63   | 010                    | 4.9              | 158                    | RIGHT                                | 2.60                                |
| 12.15              | C2-74   | 010                    | 7.4              | 158                    | RIGHT                                | 3.92                                |
| 12.25              | C2-76   | 010                    | 5.8              | 225                    | LEFT                                 | 3.33                                |
| 9.15               | D1-34   | 190                    | 2.1              | 248                    | RIGHT                                | 1.78                                |
| 9.19               | D1-34-1 | 190                    | 3.1              | 203                    | RIGHT                                | 0.70                                |
| 9.28               | D1-38   | 190                    | 1.9              | 203                    | RIGHT                                | 0.43                                |
| 9.33               | D1-38-1 | 190                    | 2.5              | 180                    | LEFT                                 | 0.43                                |
| 11.13              | D1-58   | 190                    | 6.6              | 158                    | LEFT                                 | 5.69                                |
| 11.23              | D1-62   | 190                    | 5.2              | 113                    | LEFT                                 | 5.07                                |
| 11.33              | D1-66   | 190                    | 9.7              | 158                    | LEFT                                 | 5.14                                |
| 12.02              | D2-70   | 190                    | 8.0              | 180                    | LEFT                                 | 1.39                                |

# Wind Data

## Japanese Test

| OPERATION<br>TIME | TAKEOFF<br>EVENT | FLIGHT<br>DIRECTION<br>(DEGREES) | WIND<br>SPEED<br>(KNOTS) | WIND<br>DIRECTION<br>(DEGREES) | CLOSE WIND COMPONENT     |       | ON TRACK COMPONENT      |       |
|-------------------|------------------|----------------------------------|--------------------------|--------------------------------|--------------------------|-------|-------------------------|-------|
|                   |                  |                                  |                          |                                | LEFT/RIGHT,<br>DIRECTION | KNOTS | HEAD/TAIL,<br>DIRECTION | KNOTS |
| 10.03             | A1-1             | 010                              | 2.9                      | 248                            | LEFT                     | 1.48  | TAIL                    | 1.54  |
| 10.05             | A1-2             | 190                              | 1.7                      | 270                            | RIGHT                    | 0.68  | HEAD                    | 0.47  |
| 10.07             | A1-3             | 010                              | 2.1                      | 015                            | LEFT                     | 1.68  | HEAD                    | 1.32  |
| 10.09             | A1-4             | 190                              | 1.7                      | 015                            | RIGHT                    | 1.21  | TAIL                    | 1.55  |
| 10.11             | A1-5             | 010                              | 2.9                      | 248                            | LEFT                     | 1.46  | TAIL                    | 1.54  |
| 10.13             | A1-6             | 190                              | 2.5                      | 248                            | RIGHT                    | 1.46  | HEAD                    | 1.54  |
| 10.15             | A1-7             | 010                              | 2.1                      | 270                            | LEFT                     | 2.07  | TAIL                    | 0.36  |
| 10.14             | A1-8             | 010                              | 1.1                      | 270                            | LEFT                     | 1.18  | TAIL                    | 0.21  |
| 10.15             | A1-9             | 190                              | 1.9                      | 290                            | RIGHT                    | 1.85  | TAIL                    | 0.43  |
| 10.16             | A1-10            | 010                              | 2.3                      | 315                            | LEFT                     | 1.88  | HEAD                    | 1.32  |
| 10.17             | A1-11            | 010                              | 2.3                      | 315                            | LEFT                     | 1.64  | HEAD                    | 2.63  |
| 10.18             | A1-12            | 010                              | 3.1                      | 336                            | LEFT                     | 3.03  | TAIL                    | 2.12  |
| 10.19             | A1-13            | 190                              | 3.7                      | 015                            | RIGHT                    | 3.65  | HEAD                    | 2.70  |
| 10.20             | A1-14            | 010                              | 4.7                      | 315                            | LEFT                     | 4.18  | TAIL                    | 0.74  |
| 10.21             | A1-15            | 010                              | 1.4                      | 248                            | LEFT                     | 1.19  | TAIL                    | 1.76  |
| 10.22             | A1-16            | 010                              | 2.3                      | 230                            | LEFT                     | 1.48  | TAIL                    | 1.76  |
| 10.23             | A1-17            | 010                              | 4.1                      | 135                            | RIGHT                    | 3.36  | TAIL                    | 2.35  |
| 10.24             | A1-18            | 010                              | 5.1                      | 113                            | RIGHT                    | 4.97  | TAIL                    | 1.15  |
| 10.25             | A1-19            | 190                              | 4.3                      | 135                            | RIGHT                    | 3.52  | TAIL                    | 2.47  |
| 10.26             | A1-20            | 010                              | 4.3                      | 113                            | RIGHT                    | 4.19  | TAIL                    | 0.97  |
| 10.27             | A1-21            | 010                              | 5.1                      | 315                            | LEFT                     | 4.18  | HEAD                    | 2.93  |
| 10.28             | A1-22            | 190                              | 7.8                      | 315                            | LEFT                     | 6.39  | HEAD                    | 4.47  |
| 10.29             | A1-23            | 010                              | 10.1                     | 270                            | LEFT                     | 9.95  | TAIL                    | 1.75  |
| 14.38             | A2-17            | 010                              | 5.1                      | 315                            | LEFT                     | 4.18  | HEAD                    | 2.93  |
| 14.40             | A2-18            | 190                              | 5.1                      | 315                            | RIGHT                    | 4.18  | TAIL                    | 2.93  |
| 14.42             | A2-19            | 010                              | 5.4                      | 336                            | LEFT                     | 3.86  | HEAD                    | 4.58  |
| 14.44             | A2-20            | 010                              | 5.1                      | 315                            | LEFT                     | 4.26  | HEAD                    | 2.98  |
| 15.12             | A2-21            | 010                              | 1.2                      | 045                            | RIGHT                    | 0.63  | HEAD                    | 0.98  |
| 15.14             | A2-22            | 190                              | 1.0                      | 068                            | LEFT                     | 0.85  | TAIL                    | 0.53  |
| 15.15             | A2-23            | 010                              | 0.8                      | 068                            | RIGHT                    | 0.66  | HEAD                    | 0.42  |
| 15.20             | A2-24            | 010                              | 2.3                      | 068                            | RIGHT                    | 1.95  | HEAD                    | 1.22  |
| 15.23             | A2-25            | 190                              | 0.3                      | 090                            | LEFT                     | 0.79  | TAIL                    | 0.14  |
| 15.25             | A2-26            | 010                              | 1.0                      | 068                            | RIGHT                    | 0.85  | HEAD                    | 0.53  |
| 15.27             | A2-27            | 010                              | 1.9                      | 090                            | RIGHT                    | 1.67  | HEAD                    | 0.33  |
| 15.35             | A2-28            | 190                              | 3.5                      | 090                            | LEFT                     | 3.45  | TAIL                    | 0.61  |
| 15.37             | A2-29            | 010                              | 3.5                      | 068                            | RIGHT                    | 2.97  | HEAD                    | 1.65  |
| 15.41             | A2-30            | 190                              | 4.3                      | 135                            | RIGHT                    | 4.01  | TAIL                    | 2.81  |
| 15.41             | A2-31            | 010                              | 4.3                      | 135                            | RIGHT                    | 4.13  | TAIL                    | 6.01  |
| 15.44             | A2-32            | 010                              | 7.8                      | 158                            | RIGHT                    | 4.13  | TAIL                    | 6.70  |
| 15.46             | A2-33            | 010                              | 6.8                      | 180                            | RIGHT                    | 1.18  | TAIL                    | 6.52  |
| 15.49             | A2-34            | 010                              | 7.0                      | 200                            | LEFT                     | 1.57  | TAIL                    | 6.56  |
| 15.50             | A2-35            | 190                              | 6.5                      | 180                            | RIGHT                    | 1.15  | TAIL                    | 5.71  |
| 15.45             | A2-36            | 010                              | 3.7                      | 248                            | LEFT                     | 0.14  | TAIL                    | 1.96  |

# Wind Data

## UK-FRG Test

| OPERATION: APPROACH | TIME  | EVENT  | FLIGHT                 | WIND             | WIND                   | CROSS WIND COMPONENT      | ON TRACK COMPONENT                  |
|---------------------|-------|--------|------------------------|------------------|------------------------|---------------------------|-------------------------------------|
|                     |       |        | DIRECTION<br>(DEGREES) | SPEED<br>(KNOTS) | DIRECTION<br>(DEGREES) | (LEFT/RIGHT)<br>DIRECTION | (HEAD/TAIL)<br>DIRECTION<br>(KNOTS) |
|                     | 9.58  | C.1.1  | 301                    | 7.0              | 330                    | RIGHT                     | 3.39 HEAD 6.12                      |
|                     | 10.08 | C.1.2  | 301                    | 9.0              | 292                    | LEFT                      | 1.41 HEAD 6.89                      |
|                     | 10.12 | C.1.3  | 301                    | 8.4              | 314                    | RIGHT                     | 1.89 HEAD 6.18                      |
|                     | 10.15 | C.1.4  | 301                    | 6.6              | 318                    | RIGHT                     | 1.93 HEAD 6.31                      |
|                     | 10.18 | C.1.5  | 301                    | 2.3              | 297                    | LEFT                      | 0.16 HEAD 2.29                      |
|                     | 10.22 | C.1.6  | 301                    | 0.7              | 181                    | LEFT                      | 0.61 TAIL 0.35                      |
|                     | 13.37 | C.1.7  | 301                    | 7.5              | 047                    | RIGHT                     | 7.21 TAIL 2.07                      |
|                     | 13.40 | C.1.8  | 301                    | 4.3              | 054                    | RIGHT                     | 3.96 TAIL 1.68                      |
|                     | 13.43 | C.1.9  | 301                    | 5.0              | 020                    | RIGHT                     | 4.91 HEAD 0.95                      |
|                     | 13.46 | C.1.10 | 301                    | 4.9              | 052                    | RIGHT                     | 4.57 TAIL 1.76                      |
|                     | 13.50 | C.1.11 | 301                    | 5.4              | 045                    | RIGHT                     | 5.24 TAIL 1.31                      |
|                     | 15.11 | C.1.12 | 301                    | 7.1              | 219                    | LEFT                      | 7.03 HEAD 0.99                      |
|                     | 16.18 | C.1.13 | 301                    | 6.3              | 231                    | LEFT                      | 5.92 HEAD 2.15                      |
|                     | 16.24 | C.1.14 | 301                    | 4.0              | 245                    | LEFT                      | 3.32 HEAD 2.24                      |
|                     | 16.27 | C.1.15 | 301                    | 4.1              | 249                    | LEFT                      | 3.23 HEAD 2.52                      |
|                     | 12.27 | C.2.1  | 301                    | 12.3             | 299                    | LEFT                      | 0.43 HEAD 12.19                     |
|                     | 12.35 | C.2.2  | 301                    | 8.7              | 298                    | LEFT                      | 0.46 HEAD 8.69                      |
|                     | 12.41 | C.2.3  | 301                    | 13.3             | 304                    | RIGHT                     | 0.70 HEAD 13.28                     |
|                     | 10.29 | C.2.4  | 301                    | 6.8              | 293                    | LEFT                      | 0.95 HEAD 6.73                      |
|                     | 10.35 | C.2.5  | 301                    | 6.1              | 289                    | LEFT                      | 1.27 HEAD 5.97                      |
|                     | 10.39 | C.2.6  | 301                    | 8.4              | 300                    | LEFT                      | 0.15 HEAD 6.40                      |
|                     | 11.36 | C.2.7  | 301                    | 8.3              | 341                    | RIGHT                     | 5.34 HEAD 6.36                      |
|                     | 11.39 | C.2.8  | 301                    | 7.2              | 319                    | RIGHT                     | 2.22 HEAD 6.85                      |
|                     | 11.42 | C.2.9  | 301                    | 6.5              | 317                    | RIGHT                     | 1.79 HEAD 6.25                      |
|                     | 11.48 | C.2.10 | 301                    | NA               | NA                     | NO X-WIND                 | NA NO H/T WIND NA                   |
|                     | 11.49 | C.2.11 | 301                    | 7.1              | 304                    | RIGHT                     | 0.37 HEAD 7.09                      |
|                     | 11.55 | C.2.12 | 301                    | 7.3              | 281                    | LEFT                      | 2.50 HEAD 6.86                      |
|                     | 12.20 | C.2.13 | 301                    | 9.4              | 308                    | RIGHT                     | 1.15 HEAD 9.33                      |
|                     | 12.23 | C.2.14 | 301                    | 10.4             | 297                    | LEFT                      | 0.73 HEAD 10.37                     |
|                     | NA    | C.2.15 | 301                    | NA               | NA                     | NO X-WIND                 | NA NO H/T WIND NA                   |
|                     | 12.29 | C.2.16 | 301                    | 8.1              | 284                    | LEFT                      | 2.37 HEAD 7.75                      |
|                     | 12.33 | C.2.17 | 301                    | 7.3              | 295                    | LEFT                      | 0.76 HEAD 7.26                      |

# Wind Data

## UK-FRG Test

| OPERATION: | LFO     | FLIGHT                 | WIND             | WIND                   | CROSS WIND COMPONENT                 | ON TRACK COMPONENT                  |
|------------|---------|------------------------|------------------|------------------------|--------------------------------------|-------------------------------------|
| TIME       | EVENT   | DIRECTION<br>(DEGREES) | SPEED<br>(KNOTS) | DIRECTION<br>(DEGREES) | (LEFT/RIGHT)<br>DIRECTION<br>(KNOTS) | (HEAD/TAIL)<br>DIRECTION<br>(KNOTS) |
| 13.54      | B.1.1   | 121                    | 5.8              | 283                    | RIGHT                                | 1.79 TAIL 5.52                      |
| 13.56      | B.1.2   | 301                    | 2.8              | 291                    | LEFT                                 | 0.49 HEAD 2.76                      |
| 13.58      | B.1.3   | 121                    | 4.6              | 295                    | RIGHT                                | 0.48 TAIL 4.57                      |
| 14.00      | B.1.4   | 301                    | 7.2              | 275                    | LEFT                                 | 3.16 HEAD 6.47                      |
| 14.01      | B.1.5   | 121                    | 8.6              | 253                    | RIGHT                                | 6.39 TAIL 5.75                      |
| 14.03      | B.1.6   | 301                    | 9.0              | 254                    | LEFT                                 | 6.58 HEAD 6.14                      |
| 14.16      | B.1.7   | 121                    | 4.0              | 296                    | RIGHT                                | 0.35 TAIL 3.98                      |
| 14.18      | B.1.8   | 301                    | 3.5              | 301                    | NO X-WIND                            | 0.00 HEAD 3.50                      |
| 9.37       | B.1.9   | 207                    | 3.6              | 240                    | RIGHT                                | 1.96 HEAD 3.02                      |
| 9.43       | B.1.10  | 027                    | 3.5              | 210                    | LEFT                                 | 0.18 TAIL 3.50                      |
| 9.45       | B.1.11  | 207                    | 2.6              | 206                    | LEFT                                 | 0.05 HEAD 2.60                      |
| 9.47       | B.1.12  | 027                    | 1.9              | 182                    | RIGHT                                | 0.80 TAIL 1.72                      |
| 9.53       | B.1.13  | 207                    | 2.4              | 230                    | RIGHT                                | 0.94 HEAD 2.21                      |
| 9.55       | B.1.14  | 027                    | 1.6              | 168                    | RIGHT                                | 1.01 TAIL 1.24                      |
| 9.59       | B.1.15  | 027                    | 0.9              | 203                    | RIGHT                                | 0.06 TAIL 0.90                      |
| 12.47      | B.2.1   | 301                    | 11.6             | 305                    | RIGHT                                | 0.81 HEAD 11.57                     |
| 12.50      | B.2.2   | 301                    | 10.8             | 312                    | RIGHT                                | 2.06 HEAD 10.60                     |
| 12.42      | B.2.3   | 301                    | 3.3              | 299                    | LEFT                                 | 0.12 HEAD 3.30                      |
| 12.45      | B.2.4   | 121                    | 6.7              | 313                    | LEFT                                 | 1.39 TAIL 6.55                      |
| 12.49      | B.2.5   | 301                    | 5.8              | 249                    | LEFT                                 | 4.57 HEAD 3.57                      |
| 12.51      | B.2.6   | 121                    | 8.7              | 315                    | LEFT                                 | 2.10 TAIL 8.44                      |
| 13.02      | B.2.7   | 121                    | 7.8              | 330                    | LEFT                                 | 3.78 TAIL 6.82                      |
| 13.05      | B.2.8   | 301                    | 8.2              | 360                    | RIGHT                                | 7.03 HEAD 4.22                      |
| 13.06      | B.2.9   | 121                    | 7.0              | 360                    | LEFT                                 | 6.00 TAIL 3.61                      |
| 13.09      | B.2.10  | 301                    | 7.8              | 360                    | RIGHT                                | 6.69 HEAD 4.62                      |
| 13.15      | B.2.11  | 301                    | 9.4              | 319                    | RIGHT                                | 2.90 HEAD 6.94                      |
| 13.17      | B.2.12  | 121                    | 11.0             | 317                    | LEFT                                 | 3.03 TAIL 10.57                     |
| 13.19      | B.2.13  | 301                    | 7.4              | 304                    | RIGHT                                | 0.39 HEAD 7.39                      |
| OPERATION: | TAKEOFF | FLIGHT                 | WIND             | WIND                   | CROSS WIND COMPONENT                 | ON TRACK COMPONENT                  |
| TIME       | EVENT   | DIRECTION<br>(DEGREES) | SPEED<br>(KNOTS) | DIRECTION<br>(DEGREES) | (LEFT/RIGHT)<br>DIRECTION<br>(KNOTS) | (HEAD/TAIL)<br>DIRECTION<br>(KNOTS) |
| 17.11      | A.1.1   | 207                    | 6.0              | 205                    | LEFT                                 | 0.21 HEAD 6.00                      |
| 17.13      | A.1.2   | 207                    | 7.1              | 307                    | RIGHT                                | 6.99 TAIL 1.23                      |
| 17.16      | A.1.3   | 207                    | 6.2              | 310                    | RIGHT                                | 6.04 TAIL 1.39                      |
| 17.18      | A.1.4   | 207                    | 6.4              | 306                    | RIGHT                                | 6.32 TAIL 1.00                      |
| 17.26      | A.1.5   | 207                    | 4.5              | 320                    | RIGHT                                | 4.14 TAIL 1.76                      |
| 17.28      | A.1.6   | 207                    | 4.5              | 284                    | RIGHT                                | 4.38 HEAD 1.01                      |
| 17.40      | A.1.7   | 207                    | 3.1              | 206                    | LEFT                                 | 0.05 HEAD 3.10                      |
| 17.42      | A.1.8   | 207                    | 3.2              | 201                    | LEFT                                 | 0.33 HEAD 3.18                      |
| 17.45      | A.1.9   | 207                    | 2.8              | 283                    | RIGHT                                | 2.72 HEAD 0.68                      |
| 11.15      | A.2.1   | 207                    | 2.2              | 287                    | RIGHT                                | 2.17 HEAD 9.38                      |
| 11.18      | A.2.2   | 207                    | 2.9              | 287                    | RIGHT                                | 2.86 HEAD 0.50                      |
| 11.20      | A.2.3   | 207                    | 3.2              | 312                    | RIGHT                                | 3.09 TAIL 0.83                      |
| 11.22      | A.2.4   | 207                    | 4.3              | 294                    | RIGHT                                | 4.29 HEAD 0.23                      |
| 11.25      | A.2.5   | 207                    | 3.5              | 274                    | RIGHT                                | 3.22 HEAD 1.37                      |
| 11.27      | A.2.6   | 207                    | 5.6              | 242                    | RIGHT                                | 3.21 HEAD 4.59                      |

# Wind Data

## US-Canadian Test

### APPROACH

| TIME  | EVENT | AIRCRAFT<br>HEADING<br>(DEGREES) | WIND<br>SPEED<br>(KNOTS) | WIND<br>DIRECTION<br>(DEGREES) | CROSS WIND COMPONET<br>(RIGHT/LEFT)<br>DIRECTION (KNOTS) | ON TRACK COMPONET<br>(HEAD/TAIL)<br>DIRECTION (KNOTS) |
|-------|-------|----------------------------------|--------------------------|--------------------------------|--|---|
| 11:26 | C-32  | 120                              | 3.90                     | 250                            | RIGHT 2.99   | TAIL 2.51   |
| 11:33 | C-34  | 120                              | 4.30                     | 165                            | RIGHT 3.04   | HEAD 3.04   |
| 11:41 | C-36  | 120                              | 4.30                     | 165                            | RIGHT 3.04   | HEAD 3.04   |
| 11:56 | C-38  | 120                              | 4.30                     | 160                            | RIGHT 2.76   | HEAD 3.29   |
| 12:03 | C-40  | 120                              | 2.60                     | 160                            | RIGHT 1.67   | HEAD 1.99   |
| 12:09 | C-42  | 120                              | 2.60                     | 160                            | RIGHT 1.67   | HEAD 1.99   |
| 12:16 | C-44  | 120                              | 3.90                     | 220                            | RIGHT 3.84   | TAIL 0.68   |
| 12:25 | C-46  | 120                              | 3.90                     | 220                            | RIGHT 3.84   | TAIL 0.68   |
| 12:31 | C-48  | 120                              | 3.90                     | 250                            | RIGHT 2.99   | TAIL 2.51   |
| 12:39 | C-50  | 120                              | 3.90                     | 250                            | RIGHT 2.99   | TAIL 2.51   |

| TIME  | EVENT | AIRCRAFT<br>HEADING<br>(DEGREES) | WIND<br>SPEED<br>(KNOTS) | WIND<br>DIRECTION<br>(DEGREES) | CROSS WIND COMPONET<br>(RIGHT/LEFT)<br>DIRECTION (KNOTS) | ON TRACK COMPONET<br>(HEAD/TAIL)<br>DIRECTION (KNOTS) |
|-------|-------|----------------------------------|--------------------------|--------------------------------|--|---|
| 08:43 | CC-10 | 120                              | 2.20                     | 130                            | RIGHT 0.38   | HEAD 2.17   |
| 08:52 | CC-12 | 120                              | 3.50                     | 170                            | RIGHT 2.68   | HEAD 2.25   |
| 08:58 | CC-14 | 120                              | 3.50                     | 170                            | RIGHT 2.68   | HEAD 2.25   |
| 10:36 | CC-16 | 120                              | 2.60                     | 190                            | RIGHT 2.44   | HEAD 0.89   |
| 10:45 | CC-18 | 120                              | 2.60                     | 180                            | RIGHT 2.25   | HEAD 1.30   |
| 10:52 | CC-20 | 120                              | 2.60                     | 180                            | RIGHT 2.25   | HEAD 1.30   |
| 10:59 | CC-22 | 120                              | 2.60                     | 180                            | RIGHT 2.25   | HEAD 1.30   |
| 11:07 | CC-24 | 120                              | 4.30                     | 230                            | RIGHT 4.04   | TAIL 1.47   |

| TIME  | EVENT | AIRCRAFT<br>HEADING<br>(DEGREES) | WIND<br>SPEED<br>(KNOTS) | WIND<br>DIRECTION<br>(DEGREES) | CROSS WIND COMPONET<br>(RIGHT/LEFT)<br>DIRECTION (KNOTS) | ON TRACK COMPONET<br>(HEAD/TAIL)<br>DIRECTION (KNOTS) |
|-------|-------|----------------------------------|--------------------------|--------------------------------|--|---|
| 11:40 | CZ-31 | 120                              | 4.30                     | 200                            | RIGHT 4.23   | HEAD 0.75   |
| 11:54 | CZ-33 | 120                              | 4.30                     | 180                            | RIGHT 3.72   | HEAD 2.15   |
| 12:01 | CZ-35 | 120                              | 5.20                     | 170                            | RIGHT 3.98   | HEAD 3.34   |
| 12:09 | CZ-37 | 120                              | 5.20                     | 170                            | RIGHT 3.98   | HEAD 3.34   |
| 12:15 | CZ-39 | 120                              | 4.30                     | 180                            | RIGHT 3.72   | HEAD 2.15   |

| TIME  | EVENT | AIRCRAFT<br>HEADING<br>(DEGREES) | WIND<br>SPEED<br>(KNOTS) | WIND<br>DIRECTION<br>(DEGREES) | CROSS WIND COMPONET<br>(RIGHT/LEFT)<br>DIRECTION (KNOTS) | ON TRACK COMPONET<br>(HEAD/TAIL)<br>DIRECTION (KNOTS) |
|-------|-------|----------------------------------|--------------------------|--------------------------------|--|---|
| 08:16 | CY- 2 | 120                              | 3.90                     | 215                            | RIGHT 3.89   | TAIL 0.34   |
| 08:27 | CY- 4 | 120                              | 3.90                     | 215                            | RIGHT 3.89   | TAIL 0.34   |
| 08:33 | CY- 6 | 120                              | 3.50                     | 210                            | RIGHT 3.50   | NO H/T WIND 0.00                                      |
| 11:40 | CY- 8 | 120                              | 3.50                     | 180                            | RIGHT 3.03   | HEAD 1.75   |
| 11:47 | CY-10 | 120                              | 4.30                     | 180                            | RIGHT 3.72   | HEAD 2.15   |
| 11:52 | CY-12 | 120                              | 4.30                     | 180                            | RIGHT 3.72   | HEAD 2.15   |
| 11:58 | CY-14 | 120                              | 4.30                     | 180                            | RIGHT 3.72   | HEAD 2.15   |
| 12:04 | CY-16 | 120                              | 6.10                     | 200                            | RIGHT 6.01   | HEAD 1.06   |
| 12:10 | CY-18 | 120                              | 6.10                     | 200                            | RIGHT 6.01   | HEAD 1.06   |

# Wind Data

## US-Canadian Test

### FLYOVER

| TIME  | EVENT | AIRCRAFT<br>HEADING<br>(DEGREES) | WIND<br>SPEED<br>(KNOTS) | WIND<br>DIRECTION<br>(DEGREES) | CROSS WIND COMPONET<br>(RIGHT/LEFT)<br>DIRECTION | (KNOTS) | ON TRACK COMPONET<br>(HEAD/TAIL)<br>DIRECTION | (KNOTS) |
|-------|-------|----------------------------------|--------------------------|--------------------------------|--|---------|---|---------|
| 08:35 | A1-1  | 300                              | 0.90                     | 360                            | RIGHT  | 0.78    | HEAD  | 0.45    |
| 08:35 | A1-2  | 120                              | 0.90                     | 360                            | LEFT   | 0.78    | TAIL  | 0.45    |
| 08:44 | A1-4  | 120                              | 0.90                     | 360                            | LEFT   | 0.78    | TAIL  | 0.45    |
| 08:46 | A1-5  | 300                              | 0.90                     | 60                             | RIGHT  | 0.78    | TAIL  | 0.45    |
| 08:49 | A1-6  | 120                              | 0.90                     | 60                             | LEFT   | 0.78    | HEAD  | 0.45    |
| 08:51 | A1-7  | 300                              | 0.90                     | 60                             | RIGHT  | 0.78    | TAIL  | 0.45    |
| 08:55 | A1-8  | 120                              | 0.90                     | 60                             | LEFT   | 0.78    | HEAD  | 0.45    |

| TIME  | EVENT | AIRCRAFT<br>HEADING<br>(DEGREES) | WIND<br>SPEED<br>(KNOTS) | WIND<br>DIRECTION<br>(DEGREES) | CROSS WIND COMPONET<br>(RIGHT/LEFT)<br>DIRECTION | (KNOTS) | ON TRACK COMPONET<br>(HEAD/TAIL)<br>DIRECTION | (KNOTS) |
|-------|-------|----------------------------------|--------------------------|--------------------------------|--|---------|---|---------|
| 08:19 | AA-1  | 120                              | 3.50                     | 190                            | RIGHT  | 3.29    | HEAD  | 1.20    |
| 08:22 | AA-2  | 300                              | 3.50                     | 190                            | LEFT   | 3.29    | TAIL  | 1.20    |
| 08:24 | AA-3  | 120                              | 3.50                     | 190                            | RIGHT  | 3.29    | HEAD  | 1.20    |
| 08:29 | AA-5  | 120                              | 3.50                     | 190                            | RIGHT  | 3.29    | HEAD  | 1.20    |
| 08:31 | AA-6  | 300                              | 4.30                     | 180                            | LEFT   | 3.72    | TAIL  | 2.15    |
| 08:34 | AA-7  | 120                              | 4.30                     | 180                            | RIGHT  | 3.72    | HEAD  | 2.15    |
| 08:36 | AA-8  | 300                              | 4.30                     | 180                            | LEFT   | 3.72    | TAIL  | 2.15    |

| TIME  | EVENT | AIRCRAFT<br>HEADING<br>(DEGREES) | WIND<br>SPEED<br>(KNOTS) | WIND<br>DIRECTION<br>(DEGREES) | CROSS WIND COMPONET<br>(RIGHT/LEFT)<br>DIRECTION | (KNOTS) | ON TRACK COMPONET<br>(HEAD/TAIL)<br>DIRECTION | (KNOTS) |
|-------|-------|----------------------------------|--------------------------|--------------------------------|--|---------|---|---------|
| 11:24 | AZ-26 | 300                              | 4.30                     | 190                            | LEFT   | 4.04    | TAIL  | 1.47    |
| 11:28 | AZ-27 | 120                              | 4.30                     | 190                            | RIGHT  | 4.04    | HEAD  | 1.47    |
| 11:30 | AZ-28 | 300                              | 4.30                     | 200                            | LEFT   | 4.23    | TAIL  | 0.75    |
| 11:33 | AZ-29 | 120                              | 4.30                     | 200                            | RIGHT  | 4.23    | HEAD  | 0.75    |
| 11:36 | AZ-30 | 300                              | 4.30                     | 200                            | LEFT   | 4.23    | TAIL  | 0.75    |

| TIME  | EVENT | AIRCRAFT<br>HEADING<br>(DEGREES) | WIND<br>SPEED<br>(KNOTS) | WIND<br>DIRECTION<br>(DEGREES) | CROSS WIND COMPONET<br>(RIGHT/LEFT)<br>DIRECTION | (KNOTS) | ON TRACK COMPONET<br>(HEAD/TAIL)<br>DIRECTION | (KNOTS) |
|-------|-------|----------------------------------|--------------------------|--------------------------------|--|---------|---|---------|
| 12:16 | AY-19 | 300                              | 4.30                     | 205                            | LEFT   | 4.28    | TAIL  | 0.37    |
| 12:20 | AY-20 | 120                              | 4.30                     | 205                            | RIGHT  | 4.28    | HEAD  | 0.37    |
| 12:23 | AY-21 | 300                              | 4.30                     | 205                            | LEFT   | 4.28    | TAIL  | 0.37    |
| 12:25 | AY-22 | 120                              | 4.30                     | 205                            | RIGHT  | 4.28    | HEAD  | 0.37    |
| 12:36 | AY-23 | 300                              | 5.20                     | 170                            | LEFT   | 3.98    | TAIL  | 3.34    |
| 12:38 | AY-24 | 120                              | 5.20                     | 170                            | RIGHT  | 3.98    | HEAD  | 3.34    |
| 12:40 | AY-25 | 300                              | 5.20                     | 170                            | LEFT   | 3.98    | TAIL  | 3.34    |
| 12:47 | AY-27 | 300                              | 5.60                     | 190                            | LEFT   | 5.26    | TAIL  | 1.92    |
| 12:51 | AY-28 | 120                              | 5.60                     | 190                            | RIGHT  | 5.26    | HEAD  | 1.92    |
| 12:54 | AY-29 | 300                              | 5.60                     | 190                            | LEFT   | 5.26    | TAIL  | 1.92    |
| 12:57 | AY-30 | 120                              | 5.60                     | 190                            | RIGHT  | 5.26    | HEAD  | 1.92    |

# Wind Data

## US-Canadian Test

### TAKEOFF

| TIME  | EVENT | AIRCRAFT<br>HEADING<br>(DEGREES) | WIND<br>SPEED<br>(KNOTS) | WIND<br>DIRECTION<br>(DEGREES) | CROSS WIND COMPONENT<br>(RIGHT/LEFT)<br>DIRECTION | ON TRACK COMPONENT<br>(HEAD/TAIL)<br>DIRECTION | ON TRACK COMPONENT<br>(HEAD/TAIL)<br>DIRECTION |
|-------|-------|----------------------------------|--------------------------|--------------------------------|---|--|--|
| 11:29 | B-33  | 300                              | 4.30                     | 165                            | LEFT  | 3.04   | TAIL   |
| 11:52 | B-37  | 300                              | 4.30                     | 160                            | LEFT  | 2.76   | TAIL   |
| 11:59 | B-39  | 300                              | 4.30                     | 160                            | LEFT  | 2.76   | TAIL   |
| 12:06 | B-41  | 300                              | 2.60                     | 160                            | LEFT  | 1.67   | TAIL   |
| 12:12 | B-43  | 300                              | 2.60                     | 160                            | LEFT  | 1.67   | TAIL   |
| 12:21 | B-45  | 300                              | 3.90                     | 220                            | LEFT  | 3.84   | HEAD   |
| 12:28 | B-47  | 300                              | 3.90                     | 220                            | LEFT  | 3.84   | HEAD   |
| 12:34 | B-49  | 300                              | 3.90                     | 250                            | LEFT  | 2.99   | HEAD   |
| 12:47 | B-52  | 300                              | 4.30                     | 230                            | LEFT  | 4.04   | HEAD   |

| TIME  | EVENT | AIRCRAFT<br>HEADING<br>(DEGREES) | WIND<br>SPEED<br>(KNOTS) | WIND<br>DIRECTION<br>(DEGREES) | CROSS WIND COMPONENT<br>(RIGHT/LEFT)<br>DIRECTION | ON TRACK COMPONENT<br>(HEAD/TAIL)<br>DIRECTION | ON TRACK COMPONENT<br>(HEAD/TAIL)<br>DIRECTION |
|-------|-------|----------------------------------|--------------------------|--------------------------------|---|--|--|
| 08:47 | BB-11 | 300                              | 3.90                     | 175                            | LEFT  | 3.19   | TAIL   |
| 08:54 | BB-13 | 300                              | 3.90                     | 175                            | LEFT  | 3.19   | TAIL   |
| 10:32 | BB-15 | 300                              | 2.60                     | 190                            | LEFT  | 2.44   | TAIL   |
| 10:41 | BB-17 | 300                              | 2.60                     | 190                            | LEFT  | 2.44   | TAIL   |
| 10:48 | BB-19 | 300                              | 2.60                     | 180                            | LEFT  | 2.25   | TAIL   |
| 11:03 | BB-23 | 300                              | 4.30                     | 230                            | LEFT  | 4.04   | HEAD   |
| 11:10 | BB-25 | 300                              | 4.30                     | 230                            | LEFT  | 4.04   | HEAD   |

| TIME  | EVENT | AIRCRAFT<br>HEADING<br>(DEGREES) | WIND<br>SPEED<br>(KNOTS) | WIND<br>DIRECTION<br>(DEGREES) | CROSS WIND COMPONENT<br>(RIGHT/LEFT)<br>DIRECTION | ON TRACK COMPONENT<br>(HEAD/TAIL)<br>DIRECTION | ON TRACK COMPONENT<br>(HEAD/TAIL)<br>DIRECTION |
|-------|-------|----------------------------------|--------------------------|--------------------------------|---|--|--|
| 11:49 | BZ-32 | 300                              | 4.30                     | 180                            | LEFT  | 3.72   | TAIL   |
| 11:57 | BZ-34 | 300                              | 4.30                     | 180                            | LEFT  | 3.72   | TAIL   |
| 12:04 | BZ-36 | 300                              | 5.20                     | 170                            | LEFT  | 3.98   | TAIL   |
| 12:12 | BZ-38 | 300                              | 5.20                     | 170                            | LEFT  | 3.98   | TAIL   |
| 12:18 | BZ-40 | 300                              | 4.30                     | 180                            | LEFT  | 3.72   | TAIL   |

| TIME  | EVENT | AIRCRAFT<br>HEADING<br>(DEGREES) | WIND<br>SPEED<br>(KNOTS) | WIND<br>DIRECTION<br>(DEGREES) | CROSS WIND COMPONENT<br>(RIGHT/LEFT)<br>DIRECTION | ON TRACK COMPONENT<br>(HEAD/TAIL)<br>DIRECTION | ON TRACK COMPONENT<br>(HEAD/TAIL)<br>DIRECTION |
|-------|-------|----------------------------------|--------------------------|--------------------------------|---|--|--|
| 08:24 | BY- 3 | 300                              | 3.90                     | 215                            | LEFT  | 3.89   | HEAD   |
| 08:30 | BY- 5 | 300                              | 3.50                     | 210                            | LEFT  | 3.50   | NO H/T WIND                                    |
| 11:44 | BY- 9 | 300                              | 4.30                     | 180                            | LEFT  | 3.72   | TAIL   |
| 11:49 | BY-11 | 300                              | 4.30                     | 180                            | LEFT  | 3.72   | TAIL   |
| 11:51 | BY-13 | 300                              | 4.30                     | 180                            | LEFT  | 3.72   | TAIL   |
| 12:01 | BY-15 | 300                              | 6.10                     | 200                            | LEFT  | 6.01   | TAIL   |
| 12:06 | BY-17 | 300                              | 6.10                     | 200                            | LEFT  | 6.01   | TAIL   |

TEMPERATURE & RELATIVE HUMIDITY  
METEOROLOGICAL DATA SUMMARY TABLE

COUNTRY : AUSTRALIA  
OPERATION : TAKEOFF

| EVENT | TIME  | TEMPERATURE<br>(DEGREES C) | RELATIVE<br>HUMIDITY (%) |
|-------|-------|----------------------------|--------------------------|
| 12    | 10:21 | 9.5                        | 70                       |
| 13    | 10:24 | 9.5                        | 70                       |
| 14    | 10:28 | 9.5                        | 70                       |
| 15    | 10:31 | 9.5                        | 70                       |
| 16    | 10:34 | 9.5                        | 70                       |
| 17    | 10:36 | 9.5                        | 70                       |
| 18    | 10:39 | 9.5                        | 70                       |
| 19    | 10:42 | 9.5                        | 70                       |
| 20    | 10:45 | 10.0                       | 65                       |
| 21    | 11:04 | 10.5                       | 65                       |
| 24    | 14:00 | 12.5                       | 50                       |
| 25    | 14:03 | 12.5                       | 50                       |
| 26    | 14:07 | 12.5                       | 50                       |
| 27    | 14:10 | 12.5                       | 50                       |
| 28    | 14:13 | 12.5                       | 50                       |
| 29    | 14:16 | 12.5                       | 50                       |

COUNTRY : AUSTRALIA  
OPERATION : APPROACH

| EVENT | TIME  | TEMPERATURE<br>(DEGREES C) | RELATIVE<br>HUMIDITY (%) |
|-------|-------|----------------------------|--------------------------|
| 8     | 09:03 | 8.0                        | 80                       |
| 9     | 09:08 | 8.0                        | 80                       |
| 10    | 09:15 | 8.0                        | 75                       |
| 11    | 09:20 | 8.0                        | 75                       |
| 22    | 11:08 | 10.5                       | 65                       |
| 23    | 11:12 | 10.5                       | 60                       |
| 30    | 14:18 | 12.5                       | 50                       |
| 37    | 15:39 | 12.5                       | 50                       |

COUNTRY : AUSTRALIA  
OPERATION : LEVEL FLYOVER

| EVENT | TIME  | TEMPERATURE<br>(DEGREES C) | RELATIVE<br>HUMIDITY (%) |
|-------|-------|----------------------------|--------------------------|
| 1     | 08:25 | 7.0                        | 75                       |
| 2     | 08:28 | 7.0                        | 75                       |
| 3     | 08:32 | 7.0                        | 75                       |
| 4     | 08:35 | 7.5                        | 75                       |
| 5     | 08:39 | 7.5                        | 75                       |
| 6     | 08:42 | 7.5                        | 75                       |
| 7     | 08:45 | 7.5                        | 80                       |
| 31    | 14:50 | 12.0                       | 50                       |
| 32    | 14:53 | 12.0                       | 50                       |
| 33    | 14:56 | 12.0                       | 50                       |
| 34    | 14:58 | 12.0                       | 50                       |
| 35    | 15:32 | 12.5                       | 50                       |
| 36    | 15:35 | 12.5                       | 50                       |

TEMPERATURE & RELATIVE HUMIDITY  
METEOROLOGICAL DATA SUMMARY TABLE

COUNTRY : JAPAN  
OPERATION : TAKEOFF

| EVENT | TIME  | DATE  | TEMPERATURE<br>(DEGREES C) | RELATIVE<br>HUMIDITY (%) |
|-------|-------|-------|----------------------------|--------------------------|
| A1- 5 | 14:02 | DEC 1 | 10.4                       | 58                       |
| A1- 9 | 14:14 | DEC 1 | 10.3                       | 68                       |
| A1-13 | 14:24 | DEC 1 | 10.3                       | 74                       |
| A1-33 | 09:13 | DEC 2 | 7.8                        | 72                       |
| A1-37 | 09:26 | DEC 2 | 8.3                        | 70                       |
| A1-41 | 09:40 | DEC 2 | 9.4                        | 68                       |
| A1-45 | 10:16 | DEC 2 | 10.8                       | 60                       |
| A1-49 | 10:24 | DEC 2 | 11.1                       | 56                       |
| A1-53 | 10:34 | DEC 2 | 11.4                       | 52                       |
| <hr/> |       |       |                            |                          |
| A2-21 | 15:12 | DEC 1 | 10.1                       | 72                       |
| A2-25 | 15:20 | DEC 1 | 10.3                       | 69                       |
| A2-29 | 15:32 | DEC 1 | 10.5                       | 65                       |
| A2-57 | 11:11 | DEC 2 | 13.1                       | 45                       |
| A2-61 | 11:21 | DEC 2 | 13.2                       | 44                       |
| A2-65 | 11:30 | DEC 2 | 13.3                       | 43                       |
| A2-69 | 12:00 | DEC 2 | 13.7                       | 48                       |
| A2-73 | 12:10 | DEC 2 | 14.1                       | 46                       |
| A2-77 | 12:20 | DEC 2 | 14.5                       | 42                       |

COUNTRY : JAPAN  
OPERATION : APPROACH

| EVENT | TIME  | DATE  | TEMPERATURE<br>(DEGREES C) | RELATIVE<br>HUMIDITY (%) |
|-------|-------|-------|----------------------------|--------------------------|
| B1- 8 | 14:10 | DEC 1 | 10.4                       | 65                       |
| B1-12 | 14:21 | DEC 1 | 10.3                       | 72                       |
| B1-16 | 14:31 | DEC 1 | 10.2                       | 78                       |
| B1-36 | 09:23 | DEC 2 | 8.2                        | 70                       |
| B1-40 | 09:37 | DEC 2 | 9.2                        | 68                       |
| B1-44 | 09:48 | DEC 2 | 9.7                        | 67                       |
| B1-48 | 10:21 | DEC 2 | 11.0                       | 57                       |
| B1-52 | 10:30 | DEC 2 | 11.3                       | 53                       |
| B1-56 | 10:40 | DEC 2 | 11.7                       | 50                       |
| <hr/> |       |       |                            |                          |
| B2-24 | 15:18 | DEC 1 | 10.2                       | 70                       |
| B2-28 | 15:29 | DEC 1 | 10.4                       | 66                       |
| B2-32 | 15:40 | DEC 1 | 10.6                       | 62                       |
| B2-60 | 11:18 | DEC 2 | 13.2                       | 44                       |
| B2-64 | 11:28 | DEC 2 | 13.3                       | 43                       |
| B2-68 | 11:39 | DEC 2 | 13.4                       | 43                       |
| B2-72 | 12:07 | DEC 2 | 14.0                       | 47                       |
| B2-76 | 12:17 | DEC 2 | 14.4                       | 43                       |
| B2-80 | 12:28 | DEC 2 | 14.9                       | 40                       |

TEMPERATURE & RELATIVE HUMIDITY  
METEOROLOGICAL DATA SUMMARY TABLE

COUNTRY : JAPAN  
OPERATION : LEVEL FLYOVER

| EVENT   | TIME  | DATE  | TEMPERATURE<br>(DEGREES C) | RELATIVE<br>HUMIDITY (%) |
|---------|-------|-------|----------------------------|--------------------------|
| C1-39.1 | 09:34 | DEC 2 | 9.0                        | 69                       |
| C1-39   | 09:30 | DEC 2 | 8.7                        | 69                       |
| C1-35   | 09:17 | DEC 2 | 7.9                        | 71                       |
| C1-35.1 | 09:21 | DEC 2 | 8.1                        | 71                       |
| <hr/>   |       |       |                            |                          |
| C2-74   | 12:15 | DEC 2 | 14.3                       | 44                       |
| C2-78   | 12:25 | DEC 2 | 14.8                       | 41                       |
| C2-59   | 11:16 | DEC 2 | 13.1                       | 44                       |
| C2-63   | 11:25 | DEC 2 | 13.3                       | 44                       |
| <hr/>   |       |       |                            |                          |
| D1-34   | 09:15 | DEC 2 | 7.8                        | 72                       |
| D1-38   | 09:28 | DEC 2 | 8.5                        | 70                       |
| D1-34.1 | 09:19 | DEC 2 | 8.0                        | 71                       |
| D1-38.1 | 09:33 | DEC 2 | 8.9                        | 69                       |
| <hr/>   |       |       |                            |                          |
| D2-58   | 11:13 | DEC 2 | 13.1                       | 45                       |
| D2-62   | 11:23 | DEC 2 | 13.2                       | 44                       |
| D2-66   | 11:33 | DEC 2 | 13.3                       | 43                       |
| D2-70   | 12:02 | DEC 2 | 13.9                       | 48                       |

TEMPERATURE & RELATIVE HUMIDITY  
METEOROLOGICAL DATA SUMMARY TABLE

COUNTRY : FRANCE AERO/STNA  
OPERATION : TAKEOFF

| EVENT | START TIME | DATE   | TEMPERATURE (DEGREES C) | RELATIVE HUMIDITY (%) |
|-------|------------|--------|-------------------------|-----------------------|
| 88.00 | 12:21      | OCT 17 | 17.6                    | 72                    |
| 89.00 | 12:23      | OCT 17 | 17.6                    | 72                    |
| 90.00 | 12:26      | OCT 17 | 17.6                    | 72                    |
| 91.00 | 12:29      | OCT 17 | 17.6                    | 72                    |
| 92.00 | 12:32      | OCT 17 | 17.6                    | 72                    |
| 93.00 | 12:34      | OCT 17 | 17.6                    | 72                    |
| 94.00 | 12:37      | OCT 17 | 17.6                    | 72                    |

COUNTRY : FRANCE AERO/STNA  
OPERATION : APPROACH

| EVENT | START TIME | DATE   | TEMPERATURE (DEGREES C) | RELATIVE HUMIDITY (%) |
|-------|------------|--------|-------------------------|-----------------------|
| 98    | 16:00      | OCT 17 | 17                      | 78.5                  |
| 99    | 16:04      | OCT 17 | 17                      | 78.5                  |
| 100   | 16:08      | OCT 17 | 17                      | 78.5                  |
| 101   | 16:11      | OCT 17 | 17                      | 78.5                  |
| 103   | 16:18      | OCT 17 | 17                      | 78.5                  |
| 104   | 16:25      | OCT 17 | 17                      | 78.0                  |
| 105   | 16:28      | OCT 17 | 17                      | 78.0                  |

COUNTRY : FRANCE AERO/STNA  
OPERATION : LEVEL FLYOVER

| EVENT | START TIME | DATE   | TEMPERATURE (DEGREES C) | RELATIVE HUMIDITY (%) |
|-------|------------|--------|-------------------------|-----------------------|
| 5     | 11:42      | OCT 16 | 17.0                    | 71.0                  |
| 6     | 11:45      | OCT 16 | 17.0                    | 71.0                  |
| 7     | 11:47      | OCT 16 | 17.0                    | 71.0                  |
| 8     | 11:50      | OCT 16 | 17.2                    | 70.8                  |
| 9     | 11:55      | OCT 16 | 17.5                    | 70.5                  |
| 10    | 11:59      | OCT 16 | 17.5                    | 70.0                  |
| 11    | 12:02      | OCT 16 | 17.8                    | 69.5                  |
| 12    | 12:04      | OCT 16 | 18.0                    | 69.0                  |
| 13    | 12:09      | OCT 16 | 18.0                    | 68.5                  |
| 14    | 12:12      | OCT 16 | 18.0                    | 68.0                  |

TEMPERATURE & RELATIVE HUMIDITY  
METEOROLOGICAL DATA SUMMARY TABLE

COUNTRY : UK/FRG  
OPERATION : TAKEOFF

| EVENT | TIME  | DATE   | TEMPERATURE<br>(DEGREES C) | RELATIVE<br>HUMIDITY (%) |
|-------|-------|--------|----------------------------|--------------------------|
| A1-1  | 17:11 | JULY 5 | 24.5                       | 38.7                     |
| A1-2  | 17:13 | JULY 5 | 24.3                       | 39.4                     |
| A1-3  | 17:16 | JULY 5 | 24.2                       | 40.9                     |
| A1-4  | 17:18 | JULY 5 | 24.2                       | 40.6                     |
| A1-5  | 17:26 | JULY 5 | 24.2                       | 41.4                     |
| A1-6  | 17:28 | JULY 5 | 24.5                       | 39.9                     |
| A1-7  | 17:40 | JULY 5 | 24.2                       | 40.0                     |
| A1-8  | 17:42 | JULY 5 | 25.2                       | 38.6                     |
| A1-9  | 17:45 | JULY 5 | 25.1                       | 38.6                     |
| <hr/> |       |        |                            |                          |
| A2-1  | 11:15 | JULY 6 | 24.1                       | 44.3                     |
| A2-2  | 11:18 | JULY 6 | 24.1                       | 41.9                     |
| A2-3  | 11:20 | JULY 6 | 24.2                       | 42.3                     |
| A2-4  | 11:22 | JULY 6 | 24.1                       | 43.1                     |
| A2-5  | 11:25 | JULY 6 | 23.8                       | 44.0                     |
| A2-6  | 11:27 | JULY 6 | 23.5                       | 40.0                     |

COUNTRY : UK/FRG  
OPERATION : APPROACH

| EVENT | TIME  | DATE   | TEMPERATURE<br>(DEGREES C) | RELATIVE<br>HUMIDITY (%) |
|-------|-------|--------|----------------------------|--------------------------|
| C1- 1 | 09:58 | JULY 3 | 16.3                       | 58.5                     |
| C1- 2 | 10:08 | JULY 3 | 17.0                       | 55.5                     |
| C1- 3 | 10:12 | JULY 3 | 15.8                       | 58.3                     |
| C1- 4 | 10:15 | JULY 3 | 16.1                       | 57.5                     |
| C1- 5 | 10:18 | JULY 3 | 16.2                       | 57.3                     |
| C1- 6 | 10:22 | JULY 3 | 16.6                       | 56.1                     |
| C1- 7 | 13:37 | JULY 4 | 20.6                       | 46.7                     |
| C1- 8 | 13:40 | JULY 4 | 20.5                       | 47.4                     |
| C1- 9 | 13:43 | JULY 4 | 20.3                       | 48.0                     |
| C1-10 | 13:46 | JULY 4 | 20.6                       | 47.5                     |
| C1-11 | 13:50 | JULY 4 | 20.5                       | 46.8                     |
| C1-12 | 15:11 | JULY 4 | 19.8                       | 63.4                     |
| C1-13 | 16:18 | JULY 4 | 20.4                       | 58.1                     |
| C1-14 | 16:24 | JULY 4 | 20.3                       | 59.8                     |
| C1-15 | 16:27 | JULY 4 | 20.3                       | 59.7                     |
| <hr/> |       |        |                            |                          |
| C2- 1 | 12:27 | JULY 2 | 16.7                       | 55.0                     |
| C2- 2 | 12:35 | JULY 2 | 17.0                       | 54.8                     |
| C3- 3 | 12:41 | JULY 2 | 17.7                       | 52.9                     |
| C2- 4 | 10:29 | JULY 3 | 16.8                       | 55.8                     |
| C2- 5 | 10:35 | JULY 3 | 17.2                       | 54.2                     |
| C2- 6 | 10:39 | JULY 3 | 16.5                       | 55.9                     |
| C2- 7 | 11:36 | JULY 3 | 17.1                       | 52.6                     |
| C2- 8 | 11:39 | JULY 3 | 17.9                       | 52.0                     |
| C2- 9 | 11:42 | JULY 3 | 17.5                       | 47.8                     |
| C2-11 | 11:49 | JULY 3 | 17.1                       | 50.0                     |
| C2-12 | 11:55 | JULY 3 | 17.9                       | 50.5                     |
| C2-14 | 12:23 | JULY 3 | 17.4                       | 49.7                     |
| C2-16 | 12:29 | JULY 3 | 17.3                       | 49.7                     |
| C2-17 | 12:33 | JULY 3 | 17.3                       | 49.6                     |

TEMPERATURE & RELATIVE HUMIDITY  
METEOROLOGICAL DATA SUMMARY TABLE

COUNTRY : UK/FRG  
OPERATION : LEVEL FLYOVER

| EVENT | TIME  | DATE   | TEMPERATURE<br>(DEGREES C) | RELATIVE<br>HUMIDITY (%) |
|-------|-------|--------|----------------------------|--------------------------|
| B1- 1 | 13:54 | JULY 3 | 18.9                       | 43.7                     |
| B1- 2 | 13:56 | JULY 3 | 18.7                       | 43.8                     |
| B1- 3 | 13:58 | JULY 3 | 18.6                       | 42.7                     |
| B1- 4 | 14:00 | JULY 3 | 19.6                       | 43.3                     |
| B1- 5 | 14:01 | JULY 3 | 19.5                       | 43.7                     |
| B1- 6 | 14:03 | JULY 3 | 19.7                       | 42.4                     |
| B1- 7 | 14:16 | JULY 3 | 18.9                       | 42.8                     |
| B1- 8 | 14:18 | JULY 3 | 19.5                       | 43.3                     |
| B1- 9 | 09:37 | JULY 6 | 20.7                       | 55.6                     |
| B1-10 | 09:43 | JULY 6 | 20.2                       | 55.9                     |
| B1-11 | 09:45 | JULY 6 | 20.2                       | 55.2                     |
| B1-13 | 09:53 | JULY 6 | 21.5                       | 53.6                     |
| B1-14 | 09:55 | JULY 6 | 20.4                       | 56.8                     |
| B1-15 | 09:59 | JULY 6 | 22.4                       | 50.6                     |
| <hr/> |       |        |                            |                          |
| B2- 1 | 12:47 | JULY 2 | 17.5                       | 52.4                     |
| B2- 2 | 12:50 | JULY 2 | 18.2                       | 50.9                     |
| B2- 3 | 12:42 | JULY 3 | 18.0                       | 47.0                     |
| B2- 4 | 12:45 | JULY 3 | 19.2                       | 46.7                     |
| B2- 5 | 12:49 | JULY 3 | 17.7                       | 47.8                     |
| B2- 7 | 13:02 | JULY 3 | 19.1                       | 47.5                     |
| B2- 8 | 13:05 | JULY 3 | 18.5                       | 48.6                     |
| B2- 9 | 13:0? | JULY 3 | 18.3                       | 48.2                     |
| B2-10 | 13:09 | JULY 3 | 18.3                       | 48.2                     |
| B2-11 | 13:15 | JULY 3 | 18.5                       | 46.7                     |
| B2-12 | 13:17 | JULY 3 | 18.0                       | 47.3                     |
| B2-13 | 13:19 | JULY 3 | 18.6                       | 47.2                     |

TEMPERATURE & RELATIVE HUMIDITY  
METEOROLOGICAL DATA SUMMARY TABLE

COUNTRY : US/CANADA  
OPERATION : TAKEOFF

| EVENT | TIME  | DATE   | TEMPERATURE<br>(DEGREES C) | RELATIVE<br>HUMIDITY (%) |
|-------|-------|--------|----------------------------|--------------------------|
| B-33  | 11:29 | AUG 27 | 25                         | 37                       |
| B-37  | 11:52 | AUG 27 | 26                         | 34                       |
| B-39  | 11:59 | AUG 27 | 26                         | 34                       |
| B-41  | 12:06 | AUG 27 | 26                         | 34                       |
| B-43  | 12:12 | AUG 27 | 26                         | 40                       |
| B-45  | 12:21 | AUG 27 | 26                         | 40                       |
| B-47  | 12:28 | AUG 27 | 26                         | 34                       |
| B-49  | 12:34 | AUG 27 | 26                         | 34                       |
| B-52  | 12:47 | AUG 27 | 27                         | 35                       |
| BB-11 | 08:47 | AUG 28 | 21                         | 60                       |
| BB-13 | 08:54 | AUG 28 | 21                         | 64                       |
| BB-15 | 10:32 | AUG 28 | 24                         | 55                       |
| BB-17 | 10:41 | AUG 28 | 24                         | 59                       |
| BB-19 | 10:48 | AUG 28 | 24                         | 59                       |
| BB-23 | 11:03 | AUG 28 | 25                         | 56                       |
| BB-25 | 11:10 | AUG 28 | 25                         | 60                       |
| BZ-32 | 11:49 | AUG 28 | 26                         | 58                       |
| BZ-34 | 11:57 | AUG 28 | 27                         | 55                       |
| BZ-36 | 12:04 | AUG 28 | 27                         | 55                       |
| BZ-38 | 12:12 | AUG 28 | 27                         | 55                       |
| BZ-40 | 12:18 | AUG 28 | 27                         | 55                       |
| BY- 3 | 08:24 | AUG 29 | 22                         | 58                       |
| BY- 5 | 08:30 | AUG 29 | 22                         | 58                       |
| BY- 9 | 11:44 | AUG 29 | 24                         | 58                       |
| BY-11 | 11:49 | AUG 29 | 24                         | 58                       |
| BY-13 | 11:15 | AUG 29 | 25                         | 58                       |
| BY-15 | 12:01 | AUG 29 | 25                         | 58                       |
| BY-17 | 12:06 | AUG 29 | 25                         | 58                       |

**TEMPERATURE & RELATIVE HUMIDITY  
METEOROLOGICAL DATA SUMMARY TABLE**

COUNTRY : US/CANADA  
OPERATION : APPROACH

| EVENT | TIME  | DATE   | TEMPERATURE<br>(DEGREES C) | RELATIVE<br>HUMIDITY (%) |
|-------|-------|--------|----------------------------|--------------------------|
| C-32  | 11:26 | AUG 27 | 25                         | 37                       |
| C-34  | 11:33 | AUG 27 | 25                         | 37                       |
| C-36  | 11:41 | AUG 27 | 26                         | 38                       |
| C-38  | 11:56 | AUG 27 | 26                         | 34                       |
| C-40  | 12:03 | AUG 27 | 26                         | 34                       |
| C-42  | 12:09 | AUG 27 | 26                         | 40                       |
| C-44  | 12:16 | AUG 27 | 26                         | 40                       |
| C-46  | 12:25 | AUG 27 | 26                         | 34                       |
| C-48  | 12:31 | AUG 27 | 26                         | 34                       |
| C-50  | 12:39 | AUG 27 | 26                         | 35                       |
| CC-10 | 08:43 | AUG 28 | 21                         | 60                       |
| CC-12 | 08:52 | AUG 28 | 21                         | 64                       |
| CC-14 | 08:58 | AUG 28 | 21                         | 64                       |
| CC-16 | 10:36 | AUG 28 | 24                         | 55                       |
| CC-18 | 10:45 | AUG 28 | 24                         | 59                       |
| CC-20 | 10:52 | AUG 28 | 25                         | 56                       |
| CC-22 | 10:59 | AUG 28 | 25                         | 56                       |
| CC-24 | 11:07 | AUG 28 | 25                         | 5656                     |
| CZ-31 | 11:40 | AUG 28 | 26                         | 58                       |
| CZ-33 | 11:54 | AUG 28 | 27                         | 55                       |
| CZ-35 | 12:01 | AUG 28 | 27                         | 55                       |
| CZ-37 | 12:09 | AUG 28 | 27                         | 55                       |
| CZ-39 | 12:15 | AUG 28 | 27                         | 55                       |
| CY- 2 | 08:16 | AUG 29 | 22                         | 61                       |
| CY- 4 | 08:27 | AUG 29 | 22                         | 58                       |
| CY- 6 | 08:33 | AUG 29 | 24                         | 58                       |
| CY- 8 | 11:40 | AUG 29 | 24                         | 58                       |
| CY-10 | 11:47 | AUG 29 | 24                         | 58                       |
| CY-12 | 11:52 | AUG 29 | 25                         | 58                       |
| CY-14 | 11:58 | AUG 29 | 25                         | 58                       |
| CY-16 | 12:04 | AUG 29 | 25                         | 58                       |
| CY-18 | 12:10 | AUG 29 | 25                         | 58                       |

TEMPERATURE & RELATIVE HUMIDITY  
METEOROLOGICAL DATA SUMMARY TABLE

COUNTRY : US/CANADA  
OPERATION : LEVEL FLYOVER

| EVENT | TIME  | DATE   | TEMPERATURE<br>(DEGREES C) | RELATIVE<br>HUMIDITY (%) |
|-------|-------|--------|----------------------------|--------------------------|
| A1-1  | 08:35 | AUG 27 | 18                         | 56                       |
| A1-2  | 08:35 | AUG 27 | 18                         | 56                       |
| A1-4  | 08:44 | AUG 27 | 18                         | 65                       |
| A1-5  | 08:46 | AUG 27 | 18                         | 65                       |
| A1-6  | 08:49 | AUG 27 | 18                         | 65                       |
| A1-7  | 08:51 | AUG 27 | 18                         | 65                       |
| A1-8  | 08:55 | AUG 27 | 20                         | 62                       |
| AA-1  | 08:19 | AUG 28 | 20                         | 68                       |
| AA-2  | 08:22 | AUG 28 | 20                         | 68                       |
| AA-3  | 08:24 | AUG 28 | 21                         | 64                       |
| AA-5  | 08:29 | AUG 28 | 21                         | 64                       |
| AA-6  | 08:31 | AUG 28 | 21                         | 64                       |
| AA-7  | 08:34 | AUG 28 | 21                         | 64                       |
| AA-8  | 08:36 | AUG 28 | 21                         | 64                       |
| AZ-26 | 11:24 | AUG 28 | 26                         | 56                       |
| AZ-27 | 11:28 | AUG 28 | 26                         | 56                       |
| AZ-28 | 11:30 | AUG 28 | 26                         | 56                       |
| AZ-29 | 11:33 | AUG 28 | 26                         | 56                       |
| AZ-30 | 11:36 | AUG 28 | 26                         | 56                       |
| AY-19 | 12:16 | AUG 29 | 25                         | 58                       |
| AY-20 | 12:20 | AUG 29 | 25                         | 58                       |
| AY-21 | 12:23 | AUG 29 | 27                         | 48                       |
| AY-22 | 12:25 | AUG 29 | 27                         | 48                       |
| AY-23 | 12:36 | AUG 29 | 27                         | 48                       |
| AY-24 | 12:38 | AUG 29 | 26                         | 60                       |
| AY-25 | 12:40 | AUG 29 | 26                         | 60                       |
| AY-27 | 12:47 | AUG 29 | 26                         | 60                       |
| AY-28 | 12:51 | AUG 29 | 24                         | 62                       |
| AY-29 | 12:54 | AUG 29 | 24                         | 62                       |
| AY-30 | 12:57 | AUG 29 | 24                         | 62                       |

**APPENDIX C**  
**US NOISE DATA IN HNMRP FINAL FORMAT**

The contents of Appendix C is as follows:

|   |    |
|---|----|
| <b>APPROACH DATA (in center - left - right format)</b>      |    |
| Pilot 1 - 1st occurrence.....                               | 2  |
| Pilot 1 - 2nd occurrence.....                               | 3  |
| Pilot 2 - 1st occurrence.....                               | 4  |
| Pilot 2 - 2nd occurrence.....                               | 5  |
| Three-microphone averages for Approach operations.....      | 6  |
| <br>  |    |
| <b>LEVEL FLYOVER DATA (in center - left - right format)</b> |    |
| Pilot 1 - 1st occurrence.....                               | 7  |
| Pilot 1 - 2nd occurrence.....                               | 8  |
| Pilot 2 - 1st occurrence.....                               | 9  |
| Pilot 2 - 2nd occurrence.....                               | 10 |
| Three-microphone averages for Level Flyover operations.     | 11 |
| <br>  |    |
| <b>TAKEOFF DATA (in center - left - right format)</b>       |    |
| Pilot 1 - 1st occurrence.....                               | 12 |
| Pilot 1 - 2nd occurrence.....                               | 13 |
| Pilot 2 - 1st occurrence.....                               | 14 |
| Pilot 2 - 2nd occurrence.....                               | 15 |
| Three-microphone averages for Takeoff operations.....       | 16 |

**Appendix C**

**US Data**

6 APPROACH PILOT I-1  
CENTERLINE CENTER

|         | EPNL | SEL  | PNLT <sub>m</sub> | AL <sub>m</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| C32     | 91.3 | 88.2 | 94.4              | 81.0            | 14.5  | 12.0  | 1.3 | 18   | 25  | 26  | 24    |
| C34     | 92.9 | 90.3 | 94.6              | 82.6            | 19.0  | 18.5  | 0.9 | 18   | 23  | 24  | 26    |
| C36     | 91.9 | 89.0 | 93.9              | 80.9            | 14.5  | 14.5  | 1.0 | 25   | 25  | 26  | 24    |
| C38     | 93.0 | 90.4 | 94.0              | 81.4            | 21.5  | 21.0  | 1.2 | 25   | 25  | 27  | 26    |
| C40     | 93.7 | 91.3 | 95.4              | 84.3            | 13.5  | 15.5  | 0.4 | 28   | 26  | 24  | 23    |
| C42     | 93.0 | 90.3 | 95.2              | 83.6            | 16.5  | 17.0  | 1.7 | 27   | 24  | 25  | 27    |
| C44     | 93.0 | 90.5 | 93.3              | 81.5            | 20.0  | 20.5  | 0.7 | 22   | 22  | 25  | 21    |
| C46     | 92.7 | 89.8 | 94.8              | 82.4            | 12.5  | 15.5  | 0.9 | 25   | 25  | 26  | 27    |
| C48     | 90.6 | 87.6 | 91.9              | 78.6            | 20.5  | 19.5  | 0.9 | 25   | 25  | 22  | 23    |
| C50     | 92.5 | 89.7 | 93.7              | 80.4            | 18.0  | 17.0  | 1.0 | 25   | 25  | 27  | 23    |
| Avg     | 92.5 | 89.7 | 94.1              | 81.7            | 17.0  | 17.1  | 1.0 | 24   | 25  | 25  | 24    |
| STD DEV | 0.9  | 1.1  | 1.0               | 1.6             | 3.2   | 2.8   | 0.3 |      |     |     |       |
| 90% CI  | 0.5  | 0.7  | 0.6               | 1.0             | 1.9   | 1.6   | 0.2 |      |     |     |       |

SIDELINE LEFT

|         | EPNL | SEL  | PNLT <sub>m</sub> | AL <sub>m</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| C32     | NA   | 82.7 | 86.1              | 71.0            | 30.5  | NA    | 1.5 | 18   | 23  | 24  | 22    |
| C34     | 88.1 | 84.2 | 87.9              | 73.4            | 34.0  | 32.0  | 1.0 | 19   | 23  | 22  | 24    |
| C36     | NA   |      |                   |                 |       |       |     |      |     |     |       |
| C38     | NA   |      |                   |                 |       |       |     |      |     |     |       |
| C40     | 87.9 | 83.8 | 88.6              | 73.2            | 31.0  | 29.0  | 1.8 | 27   | 23  | 24  | 27    |
| C42     | 87.4 | 83.7 | 88.0              | 73.7            | 24.5  | 23.0  | 1.6 | 27   | 24  | 23  | 25    |
| C44     | 87.1 | 83.7 | 85.7              | 72.0            | 39.5  | 38.0  | 1.5 | 27   | 24  | 23  | 25    |
| C46     | 86.6 | 82.7 | 87.2              | 71.9            | 33.5  | 31.0  | 1.3 | 23   | 23  | 22  | 24    |
| C48     | 86.5 | 83.3 | 86.4              | 73.0            | 33.5  | 32.0  | 1.6 | 28   | 25  | 24  | 26    |
| C50     | 86.9 | 83.1 | 85.5              | 71.5            | 40.5  | 40.0  | 1.3 | 27   | 24  | 23  | 25    |
| Avg     | 87.2 | 83.4 | 86.9              | 72.5            | 33.4  | 32.1  | 1.5 | 25   | 24  | 23  | 25    |
| STD DEV | 0.6  | 0.5  | 1.2               | 1.0             | 5.1   | 5.6   | 0.3 |      |     |     |       |
| 90% CI  | 0.5  | 0.4  | 0.8               | 0.7             | 3.4   | 4.1   | 0.2 |      |     |     |       |

SIDELINE RIGHT

|         | EPNL | SEL  | PNLT <sub>m</sub> | AL <sub>m</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| C32     | 91.9 | 89.0 | 91.1              | 77.8            | 26.0  | 24.0  | 1.7 | 27   | 24  | 27  | 26    |
| C34     | 91.1 | 88.3 | 91.9              | 78.2            | 27.0  | 25.5  | 1.9 | 27   | 24  | 23  | 27    |
| C36     | 91.7 | 89.0 | 91.5              | 77.8            | 34.5  | 34.0  | 1.8 | 27   | 23  | 24  | 27    |
| C38     | 91.7 | 88.8 | 91.7              | 78.0            | 22.0  | 21.5  | 1.9 | 27   | 23  | 27  | 24    |
| C40     | 90.4 | 87.6 | 91.7              | 78.0            | 26.5  | 25.0  | 1.7 | 27   | 24  | 23  | 27    |
| C42     | 88.9 | 86.0 | 88.4              | 75.7            | 23.5  | 23.5  | 2.0 | 27   | 24  | 27  | 23    |
| C44     | 90.6 | 88.0 | 89.4              | 76.2            | 31.5  | 30.5  | 1.5 | 27   | 25  | 24  | 23    |
| C46     | 92.4 | 89.8 | 91.8              | 79.0            | 28.5  | 27.0  | 0.9 | 23   | 23  | 24  | 26    |
| C48     | 90.5 | 87.6 | 91.2              | 77.9            | 24.5  | 24.5  | 1.3 | 27   | 24  | 27  | 23    |
| C50     | 90.8 | 87.9 | 90.4              | 77.6            | 24.0  | 23.5  | 0.7 | 27   | 24  | 23  | 26    |
| Avg     | 91.0 | 88.2 | 90.9              | 77.6            | 26.8  | 25.9  | 1.6 | 27   | 24  | 25  | 25    |
| STD DEV | 1.0  | 1.0  | 1.2               | 1.0             | 3.8   | 3.7   | 0.4 |      |     |     |       |
| 90% CI  | 0.6  | 0.6  | 0.7               | 0.6             | 2.2   | 2.2   | 0.2 |      |     |     |       |

6 APPROACH PILOT 1-2  
CENTERLINE CENTER

|         | EPNL | SEL  | PNLT <sub>b</sub> | AL <sub>a</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| CZ31    | 93.0 | 90.4 | 94.3              | 82.2            | 19.5  | 20.0  | 0.7 | 25   | 25  | 22  | 23    |
| CZ33    | 93.0 | 90.1 | 94.0              | 80.8            | 20.0  | 19.5  | 0.8 | 24   | 24  | 25  | 26    |
| CZ35    | 93.0 | 90.4 | 93.4              | 81.0            | 17.0  | 18.0  | 1.0 | 25   | 25  | 26  | 27    |
| CZ37    | 92.6 | 89.7 | 94.9              | 82.0            | 19.5  | 19.0  | 0.9 | 25   | 25  | 24  | 26    |
| CZ39    | 92.1 | 89.7 | 93.6              | 81.5            | 18.0  | 18.5  | 0.8 | 25   | 25  | 23  | 26    |
| Avg     | 92.7 | 90.1 | 94.0              | 81.5            | 18.8  | 19.0  | 0.9 | 25   | 25  | 24  | 26    |
| STD DEV | 0.4  | 0.4  | 0.6               | 0.6             | 1.3   | 0.8   | 0.1 |      |     |     |       |
| 90% CI  | 0.4  | 0.3  | 0.6               | 0.6             | 1.2   | 0.8   | 0.1 |      |     |     |       |

SIDELINE LEFT

|         | EPNL | SEL  | PNLT <sub>b</sub> | AL <sub>a</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| CZ31    | 87.6 | 84.2 | 86.9              | 72.5            | 29.5  | 24.0  | 0.9 | 22   | 23  | 24  | 22    |
| CZ33    | 87.0 | 83.4 | 87.6              | 72.3            | 37.5  | 24.5  | 1.3 | 23   | 23  | 26  | 24    |
| CZ35    | 86.4 | 83.0 | 85.2              | 72.2            | 36.5  | 36.0  | 1.3 | 28   | 25  | 24  | 26    |
| CZ37    | 85.9 | 82.6 | 84.3              | 70.4            | 36.5  | 29.5  | 0.9 | 26   | 23  | 22  | 24    |
| CZ39    | 87.8 | 84.7 | 87.8              | 73.4            | 31.0  | 21.0  | 1.6 | 27   | 24  | 23  | 25    |
| Avg     | 86.9 | 83.6 | 86.3              | 72.2            | 34.2  | 27.0  | 1.2 | 25   | 24  | 24  | 24    |
| STD DEV | 0.8  | 0.9  | 1.5               | 1.1             | 3.7   | 5.9   | 0.3 |      |     |     |       |
| 90% CI  | 0.8  | 0.8  | 1.5               | 1.0             | 3.5   | 5.6   | 0.3 |      |     |     |       |

SIDELINE RIGHT

|         | EPNL | SEL  | PNLT <sub>b</sub> | AL <sub>a</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| CZ31    | 90.4 | 87.6 | 90.4              | 76.8            | 25.5  | 23.0  | 1.4 | 27   | 24  | 23  | 27    |
| CZ33    | 90.8 | 87.9 | 89.9              | 77.1            | 26.5  | 26.0  | 0.7 | 26   | 23  | 24  | 26    |
| CZ35    | 91.7 | 89.1 | 92.1              | 78.5            | 26.5  | 17.5  | 2.0 | 27   | 24  | 27  | 25    |
| CZ37    | 90.9 | 88.0 | 91.2              | 78.6            | 23.0  | 23.0  | 0.9 | 24   | 24  | 23  | 26    |
| CZ39    | 88.4 | 85.7 | 87.4              | 73.2            | 32.0  | 30.5  | 1.6 | 27   | 24  | 27  | 23    |
| Avg     | 90.4 | 87.7 | 90.2              | 76.8            | 26.7  | 24.0  | 1.3 | 26   | 24  | 25  | 25    |
| STD DEV | 1.2  | 1.3  | 1.8               | 2.2             | 3.3   | 4.8   | 0.5 |      |     |     |       |
| 90% CI  | 1.2  | 1.2  | 1.7               | 2.1             | 3.1   | 4.5   | 0.5 |      |     |     |       |

6 APPROACH PILOT 2-1  
CENTERLINE CENTER

|         | EPNL | SEL  | PNLT <sub>m</sub> | AL <sub>a</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| CC10    | 92.9 | 90.2 | 94.8              | 81.6            | 15.0  | 14.5  | 1.0 | 28   | 25  | 24  | 22    |
| CC12    | 92.9 | 90.1 | 96.1              | 83.2            | 13.0  | 13.0  | 1.0 | 25   | 25  | 24  | 26    |
| CC14    | 90.4 | 87.4 | 93.2              | 80.3            | 14.0  | 13.5  | 1.1 | 25   | 25  | 26  | 24    |
| CC16    | 90.4 | 87.7 | 93.8              | 81.2            | 13.5  | 14.0  | 0.7 | 25   | 25  | 24  | 26    |
| CC18    | 93.4 | 91.1 | 94.8              | 82.3            | 13.5  | 13.0  | 1.0 | 25   | 25  | 27  | 26    |
| CC20    | 92.9 | 90.1 | 94.3              | 81.7            | 14.5  | 14.0  | 0.7 | 25   | 25  | 24  | 26    |
| CC22    | 93.5 | 90.9 | 94.2              | 82.3            | 16.0  | 16.5  | 0.5 | 25   | 25  | 23  | 22    |
| CC24    | 93.2 | 90.5 | 95.1              | 82.2            | 16.0  | 14.5  | 1.1 | 25   | 25  | 26  | 24    |
| Avg     | 92.4 | 89.7 | 94.5              | 81.9            | 14.4  | 14.1  | 0.9 | 25   | 25  | 25  | 25    |
| STD DEV | 1.3  | 1.4  | 0.9               | 0.9             | 1.1   | 1.1   | 0.2 |      |     |     |       |
| 90% CI  | 0.9  | 0.9  | 0.6               | 0.6             | 0.8   | 0.8   | 0.2 |      |     |     |       |

SIDELINE LEFT

|         | EPNL | SEL  | PNLT <sub>m</sub> | AL <sub>a</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| CC10    | 85.7 | 82.2 | 86.9              | 71.6            | 36.0  | 19.0  | 1.3 | 23   | 23  | 22  | 26    |
| CC12    | 86.1 | 82.3 | 86.5              | 71.8            | 32.5  | 28.0  | 1.3 | 19   | 23  | 22  | 24    |
| CC14    | NA   |      |                   |                 |       |       |     |      |     |     |       |
| CC16    | 85.0 | 81.8 | 83.7              | 70.0            | 45.5  | 35.0  | 1.3 | 27   | 23  | 35  | 24    |
| CC18    | 85.8 | 82.5 | 85.5              | 70.8            | 30.5  | 27.5  | 1.5 | 27   | 23  | 24  | 25    |
| CC20    | 87.0 | 83.2 | 86.2              | 71.3            | 37.5  | 33.0  | 1.4 | 19   | 23  | 24  | 33    |
| CC22    | 88.7 | 85.0 | 88.4              | 74.2            | 29.5  | 28.5  | 1.9 | 27   | 24  | 23  | 25    |
| CC24    | 86.4 | 82.6 | 86.8              | 71.6            | 31.0  | 27.0  | 1.4 | 19   | 23  | 24  | 26    |
| Avg     | 86.4 | 82.8 | 86.3              | 71.6            | 34.6  | 28.3  | 1.4 | 23   | 23  | 25  | 26    |
| STD DEV | 1.2  | 1.1  | 1.4               | 1.3             | 5.6   | 5.1   | 0.2 |      |     |     |       |
| 90% CI  | 0.9  | 0.8  | 1.1               | 1.0             | 4.1   | 3.7   | 0.1 |      |     |     |       |

SIDELINE RIGHT

|         | EPNL | SEL  | PNLT <sub>m</sub> | AL <sub>a</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| CC10    | 92.1 | 89.4 | 91.3              | 79.2            | 22.0  | 22.0  | 2.7 | 28   | 28  | 27  | 26    |
| CC12    | 90.9 | 88.2 | 90.5              | 77.4            | 26.0  | 25.5  | 1.3 | 27   | 24  | 23  | 27    |
| CC14    | 88.5 | 86.1 | 89.0              | 76.6            | 28.0  | 28.0  | 1.4 | 27   | 27  | 26  | 24    |
| CC16    | 90.4 | 88.0 | 91.6              | 78.9            | 18.5  | 17.5  | 1.1 | 24   | 24  | 26  | 23    |
| CC18    | 90.8 | 87.9 | 91.3              | 78.3            | 22.0  | 20.5  | 2.0 | 27   | 24  | 25  | 27    |
| CC20    | 91.8 | 89.6 | 91.7              | 78.6            | 25.5  | 19.0  | 1.8 | 27   | 24  | 23  | 27    |
| CC22    | 90.1 | 87.2 | 92.1              | 78.7            | 17.5  | 16.0  | 1.8 | 27   | 23  | 27  | 24    |
| CC24    | 91.5 | 88.9 | 91.1              | 77.2            | 34.0  | 33.0  | 2.2 | 27   | 24  | 27  | 25    |
| Avg     | 90.8 | 88.2 | 91.1              | 78.1            | 24.2  | 22.7  | 1.8 | 27   | 25  | 26  | 25    |
| STD DEV | 1.1  | 1.1  | 1.0               | 0.9             | 5.4   | 5.8   | 0.5 |      |     |     |       |
| 90% CI  | 0.8  | 0.8  | 0.6               | 0.6             | 3.6   | 3.9   | 0.4 |      |     |     |       |

6° APPROACH PILOT 2-2  
CENTERLINE CENTER

|         | EPNL | SEL  | PNLT <sub>m</sub> | AL <sub>m</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| CY2     | 92.1 | 89.3 | 94.3              | 81.1            | 12.5  | 12.0  | 1.1 | 25   | 25  | 26  | 24    |
| CY4     | 92.9 | 90.0 | 93.5              | 80.7            | 15.5  | 16.0  | 0.8 | 22   | 24  | 22  | 25    |
| CY6     | 92.8 | 90.1 | 93.8              | 81.0            | 15.0  | 15.0  | 0.8 | 25   | 25  | 23  | 26    |
| CY8     | 92.8 | 89.9 | 93.3              | 81.0            | 15.5  | 15.5  | 0.8 | 25   | 25  | 23  | 22    |
| CY10    | 93.6 | 90.7 | 94.1              | 81.1            | 18.5  | 18.5  | 0.7 | 25   | 25  | 24  | 26    |
| CY12    | 92.3 | 89.4 | 94.9              | 82.4            | 14.5  | 15.5  | 0.9 | 27   | 25  | 27  | 24    |
| CY14    | 92.8 | 90.0 | 94.3              | 81.8            | 17.0  | 17.0  | 0.8 | 25   | 25  | 26  | 23    |
| CY16    | 93.3 | 90.6 | 94.8              | 82.7            | 15.5  | 17.0  | 0.9 | 27   | 25  | 27  | 23    |
| CY18    | 92.6 | 90.1 | 95.0              | 82.4            | 17.5  | 17.5  | 0.8 | 25   | 25  | 27  | 23    |
| AVG     | 92.8 | 90.0 | 94.2              | 81.6            | 15.7  | 16.0  | 0.8 | 25   | 25  | 25  | 24    |
| STD DEV | 0.4  | 0.5  | 0.6               | 0.7             | 1.8   | 1.9   | 0.1 |      |     |     |       |
| 90% CI  | 0.3  | 0.3  | 0.4               | 0.5             | 1.1   | 1.2   | 0.1 |      |     |     |       |

SIDELINE LEFT

|         | EPNL | SEL  | PNLT <sub>m</sub> | AL <sub>m</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| CY2     | 86.1 | 82.6 | 85.8              | 70.9            | 36.0  | 24.5  | 1.2 | 19   | 23  | 24  | 35    |
| CY4     | 87.2 | 83.9 | 85.4              | 71.7            | 45.5  | 26.5  | 1.4 | 27   | 33  | 32  | 24    |
| CY6     | NA   | 83.4 | 87.6              | 73.4            | 16.0  | NA    | 1.6 | 27   | 24  | 23  | 25    |
| CY8     | 87.6 | 84.2 | 87.2              | 73.6            | 36.0  | 32.5  | 0.8 | 27   | 24  | 23  | 25    |
| CY10    | 86.9 | 83.5 | 85.4              | 71.6            | 42.0  | 30.5  | 1.5 | 27   | 23  | 24  | 27    |
| CY12    | 86.7 | 83.0 | 86.9              | 71.9            | 36.0  | 29.5  | 1.2 | 19   | 23  | 22  | 26    |
| CY14    | 87.1 | 83.7 | 86.1              | 72.7            | 42.5  | 34.5  | 1.5 | 28   | 25  | 24  | 26    |
| CY16    | 87.9 | 84.6 | 88.0              | 73.6            | 31.0  | 23.5  | 1.1 | 19   | 23  | 24  | 22    |
| CY18    | 87.4 | 84.0 | 88.5              | 74.1            | 28.0  | 19.0  | 1.8 | 27   | 24  | 23  | 25    |
| AVG     | 87.1 | 83.7 | 86.7              | 72.6            | 34.8  | 27.6  | 1.4 | 24   | 25  | 24  | 26    |
| STD DEV | 0.6  | 0.6  | 1.1               | 1.1             | 9.0   | 5.1   | 0.3 |      |     |     |       |
| 90% CI  | 0.4  | 0.4  | 0.7               | 0.7             | 5.6   | 3.4   | 0.2 |      |     |     |       |

SIDELINE RIGHT

|         | EPNL | SEL  | PNLT <sub>m</sub> | AL <sub>m</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| CY2     | 90.7 | 88.0 | 91.0              | 77.6            | 20.0  | 17.0  | 1.7 | 27   | 25  | 27  | 23    |
| CY4     | 92.1 | 89.4 | 92.4              | 78.7            | 23.5  | 20.0  | 1.9 | 27   | 24  | 27  | 23    |
| CY6     | 91.2 | 88.4 | 91.8              | 78.3            | 24.0  | 23.0  | 1.7 | 27   | 24  | 27  | 23    |
| CY8     | 92.1 | 89.0 | 93.0              | 78.7            | 22.0  | 19.0  | 2.0 | 27   | 24  | 23  | 25    |
| CY10    | 92.3 | 89.1 | 92.7              | 78.7            | 25.0  | 22.5  | 1.9 | 27   | 24  | 23  | 27    |
| CY12    | 91.9 | 89.1 | 93.0              | 80.4            | 20.0  | 19.5  | 1.3 | 27   | 24  | 23  | 27    |
| CY14    | 92.6 | 89.3 | 92.9              | 78.8            | 24.0  | 23.0  | 2.3 | 27   | 24  | 27  | 23    |
| CY16    | 90.6 | 87.7 | 91.7              | 78.7            | 20.0  | 20.0  | 1.7 | 27   | 24  | 27  | 25    |
| CY18    | 89.1 | 86.2 | 89.3              | 75.8            | 25.5  | 23.5  | 1.4 | 27   | 24  | 25  | 23    |
| AVG     | 91.4 | 88.5 | 92.0              | 78.4            | 22.7  | 20.8  | 1.8 | 27   | 24  | 25  | 24    |
| STD DEV | 1.1  | 1.0  | 1.2               | 1.2             | 2.2   | 2.2   | 0.3 |      |     |     |       |
| 90% CI  | 0.7  | 0.6  | 0.8               | 0.8             | 1.4   | 1.4   | 0.2 |      |     |     |       |

# APPROACH

## Three Mic Averages

### Pilot 1-1

|         | EPNL | SEL  | PNLT <sub>m</sub> | AL <sub>a</sub> |
|---------|------|------|-------------------|-----------------|
| C32     | NA   | 86.6 | 90.5              | 76.6            |
| C34     | 90.7 | 87.6 | 91.5              | 78.1            |
| C36     | NA   | NA   | NA                | NA              |
| C38     | NA   | NA   | NA                | NA              |
| C40     | 90.7 | 87.6 | 91.9              | 78.5            |
| C42     | 89.8 | 86.7 | 90.5              | 77.7            |
| C44     | 90.2 | 87.4 | 89.5              | 76.6            |
| C46     | 90.6 | 87.4 | 91.3              | 77.8            |
| C48     | 89.2 | 86.2 | 89.8              | 76.5            |
| C50     | 90.0 | 86.9 | 89.9              | 76.5            |
| Avg     | 90.2 | 87.1 | 90.6              | 77.3            |
| STD DEV | 0.6  | 0.5  | 0.9               | 0.8             |
| 90% CI  | 0.4  | 0.4  | 0.6               | 0.6             |

### Pilot 1-2

|         | EPNL | SEL  | PNLT <sub>m</sub> | AL <sub>a</sub> |
|---------|------|------|-------------------|-----------------|
| CZ31    | 90.3 | 87.4 | 90.5              | 77.2            |
| CZ33    | 90.3 | 87.1 | 90.5              | 76.7            |
| CZ35    | 90.4 | 87.5 | 90.2              | 77.2            |
| CZ37    | 89.8 | 86.8 | 90.1              | 77.0            |
| CZ39    | 89.4 | 86.7 | 89.6              | 76.0            |
| Avg     | 90.0 | 87.1 | 90.2              | 76.8            |
| STD DEV | 0.4  | 0.4  | 0.4               | 0.5             |
| 90% CI  | 0.4  | 0.3  | 0.4               | 0.5             |

### Pilot 2-1

|         | EPNL | SEL  | PNLT <sub>m</sub> | AL <sub>a</sub> |
|---------|------|------|-------------------|-----------------|
| CC10    | 90.2 | 87.3 | 91.0              | 77.5            |
| CC12    | 90.0 | 86.9 | 91.0              | 77.5            |
| CC14    | NA   | NA   | NA                | NA              |
| CC16    | 88.6 | 85.8 | 89.7              | 76.7            |
| CC18    | 90.0 | 87.2 | 90.5              | 77.1            |
| CC20    | 90.6 | 87.6 | 90.7              | 77.2            |
| CC22    | 90.8 | 87.7 | 91.6              | 78.4            |
| CC24    | 90.4 | 87.3 | 91.0              | 77.0            |
| Avg     | 90.1 | 87.1 | 90.8              | 77.3            |
| STD DEV | 0.7  | 0.6  | 0.6               | 0.5             |
| 90% CI  | 0.5  | 0.5  | 0.4               | 0.4             |

### Pilot 2-2

|         | EPNL | SEL  | PNLT <sub>m</sub> | AL <sub>a</sub> |
|---------|------|------|-------------------|-----------------|
| CY2     | 89.6 | 86.7 | 90.4              | 76.5            |
| CY4     | 90.7 | 87.8 | 90.4              | 77.0            |
| CY6     | NA   | 87.3 | 91.1              | 77.6            |
| CY8     | 90.8 | 87.7 | 91.2              | 77.8            |
| CY10    | 90.9 | 87.8 | 90.7              | 77.1            |
| CY12    | 90.3 | 87.2 | 91.6              | 78.2            |
| CY14    | 90.8 | 87.7 | 91.1              | 77.8            |
| CY16    | 90.6 | 87.6 | 91.5              | 78.3            |
| CY18    | 89.7 | 86.8 | 90.9              | 77.4            |
| Avg     | 90.5 | 87.4 | 91.0              | 77.5            |
| STD DEV | 0.5  | 0.4  | 0.4               | 0.6             |
| 90% CI  | 0.4  | 0.3  | 0.3               | 0.4             |

LEVEL FLYOVER PILOT 1-1  
CENTERLINE CENTER

|         | EPNL | SEL  | PNLT <sub>a</sub> | ALM  | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|------|-------|-------|-----|------|-----|-----|-------|
| A1      | 87.2 | 83.8 | 89.4              | 76.0 | 12.5  | 10.5  | 1.1 | 23   | 23  | 26  | 27    |
| A2      | 87.2 | 83.9 | 89.3              | 75.8 | 14.0  | 13.5  | 1.2 | 23   | 23  | 26  | 27    |
| A4      | 87.2 | 83.9 | 88.7              | 75.5 | 16.0  | 16.0  | 1.0 | 23   | 26  | 23  | 27    |
| A5      | 86.6 | 83.2 | 89.4              | 75.5 | 12.0  | 10.0  | 1.3 | 23   | 23  | 26  | 27    |
| A6      | 86.6 | 83.3 | 88.9              | 75.6 | 13.0  | 13.5  | 1.1 | 22   | 26  | 23  | 27    |
| A7      | 86.3 | 83.2 | 88.9              | 75.6 | 13.0  | 10.0  | 1.0 | 23   | 23  | 26  | 22    |
| A8      | 86.8 | 83.6 | 89.1              | 75.5 | 15.5  | 15.0  | 1.2 | 23   | 23  | 26  | 27    |
| AVG     | 86.8 | 83.6 | 89.1              | 75.6 | 13.7  | 12.6  | 1.1 | 23   | 24  | 25  | 26    |
| STD DEV | 0.4  | 0.3  | 0.3               | 0.2  | 1.5   | 2.5   | 0.1 |      |     |     |       |
| 90% CI  | 0.3  | 0.2  | 0.2               | 0.1  | 1.1   | 1.8   | 0.1 |      |     |     |       |

SIDELINE LEFT SITE 2 & 3

|         | EPNL | SEL  | PNLT <sub>a</sub> | ALM  | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|------|-------|-------|-----|------|-----|-----|-------|
| A1      | 87.4 | 83.9 | 88.2              | 74.2 | 18.5  | 17.5  | 1.7 | 22   | 23  | 33  | 32    |
| A2      | 87.2 | 83.5 | 87.4              | 73.2 | 24.0  | 22.0  | 1.6 | 20   | 23  | 33  | 32    |
| A4      | 87.9 | 84.2 | 88.4              | 73.9 | 24.5  | 21.5  | 1.5 | 22   | 23  | 22  | 33    |
| A5      | 87.1 | 84.0 | 87.6              | 73.9 | 20.0  | 18.5  | 1.8 | 22   | 33  | 34  | 32    |
| A6      | 87.1 | 83.5 | 88.1              | 74.0 | 21.0  | 19.5  | 1.7 | 20   | 23  | 33  | 34    |
| A7      | 87.2 | 83.7 | 88.3              | 74.5 | 20.0  | 19.0  | 1.7 | 20   | 23  | 34  | 33    |
| A8      | 87.4 | 83.8 | 87.8              | 73.4 | 24.0  | 22.0  | 2.1 | 20   | 23  | 33  | 32    |
| AVG     | 87.3 | 83.8 | 88.0              | 73.9 | 21.7  | 20.0  | 1.7 | 21   | 24  | 32  | 33    |
| STD DEV | 0.3  | 0.3  | 0.4               | 0.5  | 2.4   | 1.8   | 0.2 |      |     |     |       |
| 90% CI  | 0.2  | 0.2  | 0.3               | 0.3  | 1.8   | 1.3   | 0.1 |      |     |     |       |

SIDELINE RIGHT SITE 2 & 3

|         | EPNL | SEL  | PNLT <sub>a</sub> | ALM  | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|------|-------|-------|-----|------|-----|-----|-------|
| A1      | 86.6 | 83.1 | 87.6              | 74.2 | 18.0  | 17.5  | 1.1 | 22   | 24  | 23  | 35    |
| A2      | 86.6 | 83.1 | 87.6              | 73.9 | 16.5  | 17.0  | 1.4 | 22   | 24  | 34  | 33    |
| A4      | 86.6 | 83.2 | 87.7              | 74.1 | 18.0  | 16.5  | 1.2 | 24   | 24  | 34  | 27    |
| A5      | 85.5 | 82.2 | 85.7              | 73.1 | 16.0  | 17.0  | 1.1 | 22   | 26  | 24  | 34    |
| A6      | 86.3 | 82.8 | 87.3              | 73.9 | 16.5  | 17.0  | 1.3 | 22   | 24  | 34  | 35    |
| A7      | 86.3 | 82.9 | 87.7              | 74.4 | 17.0  | 16.0  | 1.4 | 22   | 24  | 22  | 23    |
| A8      | 86.3 | 83.0 | 87.2              | 73.9 | 17.5  | 17.5  | 1.3 | 22   | 24  | 35  | 24    |
| AVG     | 86.3 | 82.9 | 87.3              | 73.9 | 17.1  | 16.9  | 1.3 | 22   | 24  | 29  | 32    |
| STD DEV | 0.4  | 0.3  | 0.7               | 0.4  | 0.8   | 0.5   | 0.1 |      |     |     |       |
| 90% CI  | 0.3  | 0.3  | 0.5               | 0.3  | 0.6   | 0.4   | 0.1 |      |     |     |       |

LEVEL FLYOVER PILOT 1-2  
CENTERLINE CENTER

|         | EPNL | SEL  | PNLT <sub>b</sub> | AL <sub>m</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| AZ27    | 87.7 | 84.1 | 90.0              | 76.2            | 13.0  | 12.5  | 1.1 | 23   | 23  | 26  | 22    |
| AZ28    | 87.9 | 84.6 | 91.2              | 77.5            | 11.0  | 10.0  | 1.2 | 23   | 23  | 26  | 27    |
| AZ29    | 87.7 | 84.3 | 91.3              | 77.1            | 13.0  | 11.5  | 1.4 | 23   | 23  | 26  | 27    |
| AZ30    | 87.6 | 84.1 | 90.0              | 76.4            | 13.5  | 13.0  | 1.1 | 23   | 23  | 26  | 27    |
| AVG     | 87.7 | 84.3 | 90.6              | 76.8            | 12.6  | 11.8  | 1.2 | 23   | 23  | 26  | 26    |
| STD DEV | 0.2  | 0.2  | 0.7               | 0.6             | 1.1   | 1.3   | 0.1 |      |     |     |       |
| 90% CI  | 0.2  | 0.3  | 0.8               | 0.7             | 1.3   | 1.6   | 0.2 |      |     |     |       |

SIDELINE LEFT SITE 2 & 3

|         | EPNL | SEL  | PNLT <sub>b</sub> | AL <sub>m</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| AZ27    | 87.8 | 84.0 | 90.1              | 75.5            | 19.5  | 17.5  | 1.5 | 22   | 23  | 34  | 32    |
| AZ28    | 87.8 | 84.4 | 89.6              | 75.4            | 20.0  | 18.0  | 1.5 | 22   | 23  | 34  | 33    |
| AZ29    | 87.5 | 83.4 | 89.4              | 74.4            | 16.5  | 16.0  | 1.6 | 22   | 23  | 22  | 24    |
| AZ30    | 87.7 | 84.3 | 89.6              | 75.8            | 17.5  | 17.0  | 1.4 | 22   | 23  | 34  | 33    |
| AVG     | 87.7 | 84.0 | 89.7              | 75.3            | 18.8  | 17.1  | 1.5 | 22   | 23  | 31  | 31    |
| STD DEV | 0.1  | 0.5  | 0.3               | 0.6             | 1.7   | 0.9   | 0.1 |      |     |     |       |
| 90% CI  | 0.2  | 0.5  | 0.4               | 0.7             | 1.9   | 1.0   | 0.1 |      |     |     |       |

SIDELINE RIGHT SITE 2 & 3

|         | EPNL | SEL  | PNLT <sub>b</sub> | AL <sub>m</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| AZ27    | 86.7 | 83.7 | 88.1              | 75.7            | 14.0  | 16.5  | 0.8 | 22   | 34  | 35  | 24    |
| AZ28    | 86.4 | 83.1 | 86.8              | 74.1            | 18.0  | 18.5  | 1.0 | 22   | 24  | 22  | 26    |
| AZ29    | 86.1 | 83.0 | 87.5              | 74.8            | 15.0  | 15.5  | 0.6 | 22   | 35  | 34  | 33    |
| AZ30    | 86.0 | 82.5 | 87.8              | 74.2            | 17.0  | 16.0  | 1.2 | 22   | 24  | 35  | 22    |
| AVG     | 86.3 | 83.1 | 87.6              | 74.7            | 16.0  | 16.6  | 0.9 | 22   | 29  | 32  | 26    |
| STD DEV | 0.3  | 0.5  | 0.6               | 0.7             | 1.8   | 1.3   | 0.3 |      |     |     |       |
| 90% CI  | 0.4  | 0.6  | 0.7               | 0.9             | 2.2   | 1.6   | 0.3 |      |     |     |       |

LEVEL FLYOVER PILOT 2-1  
CENTERLINE CENTER

|         | EPNL | SEL  | PNLT | AL   | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|------|------|-------|-------|-----|------|-----|-----|-------|
| AA2     | 87.6 | 84.3 | 90.1 | 76.3 | 14.0  | 12.0  | 1.2 | 23   | 23  | 26  | 27    |
| AA3     | 88.2 | 84.9 | 90.2 | 76.2 | 13.5  | 13.0  | 1.4 | 23   | 23  | 26  | 27    |
| AA5     | 87.0 | 84.0 | 89.2 | 76.0 | 17.5  | 16.5  | 1.1 | 23   | 26  | 23  | 27    |
| AA6     | 87.4 | 84.2 | 90.1 | 77.2 | 12.0  | 12.0  | 0.9 | 23   | 26  | 23  | 27    |
| AA7     | 87.4 | 84.0 | 90.4 | 76.3 | 14.5  | 12.0  | 1.2 | 23   | 23  | 26  | 27    |
| AA8     | 87.1 | 83.7 | 89.6 | 76.2 | 12.0  | 12.0  | 1.1 | 23   | 23  | 26  | 27    |
| Avg     | 87.5 | 84.2 | 89.9 | 76.4 | 13.9  | 12.9  | 1.2 | 23   | 24  | 25  | 27    |
| STD DEV | 0.4  | 0.4  | 0.4  | 0.4  | 2.0   | 1.8   | 0.1 |      |     |     |       |
| 90% CI  | 0.4  | 0.3  | 0.4  | 0.3  | 1.7   | 1.5   | 0.1 |      |     |     |       |

SIDELINE LEFT SITE 2 & 3

|         | EPNL | SEL  | PNLT | AL   | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|------|------|-------|-------|-----|------|-----|-----|-------|
| AA2     | 87.3 | 84.1 | 88.5 | 74.8 | 18.5  | 16.0  | 1.9 | 20   | 33  | 23  | 34    |
| AA3     | 87.2 | 83.8 | 88.4 | 74.3 | 21.0  | 19.5  | 2.1 | 20   | 23  | 32  | 33    |
| AA5     | 87.3 | 83.7 | 89.6 | 74.5 | 22.5  | 16.0  | 1.7 | 22   | 23  | 22  | 34    |
| AA6     | 87.1 | 83.8 | 89.4 | 75.4 | 15.0  | 14.0  | 2.0 | 20   | 33  | 34  | 23    |
| AA7     | 87.2 | 83.8 | 88.8 | 74.7 | 21.0  | 19.0  | 1.8 | 22   | 23  | 32  | 33    |
| AA8     | 87.7 | 84.3 | 89.4 | 75.4 | 15.0  | 14.5  | 1.9 | 22   | 23  | 22  | 33    |
| Avg     | 87.3 | 83.9 | 89.0 | 74.9 | 18.8  | 16.5  | 1.9 | 21   | 26  | 28  | 32    |
| STD DEV | 0.2  | 0.2  | 0.5  | 0.5  | 3.2   | 2.3   | 0.1 |      |     |     |       |
| 90% CI  | 0.2  | 0.2  | 0.4  | 0.4  | 2.7   | 1.9   | 0.1 |      |     |     |       |

SIDELINE RIGHT SITE 2 & 3

|         | EPNL | SEL  | PNLT | AL   | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|------|------|-------|-------|-----|------|-----|-----|-------|
| AA2     | 86.4 | 83.2 | 87.9 | 74.7 | 16.5  | 16.0  | 1.2 | 22   | 24  | 23  | 26    |
| AA3     | 86.6 | 83.7 | 87.7 | 74.8 | 16.5  | 16.0  | 1.1 | 22   | 24  | 22  | 28    |
| AA5     | 85.6 | 82.7 | 87.4 | 74.0 | 18.5  | 17.5  | 1.3 | 22   | 24  | 34  | 33    |
| AA6     | 86.4 | 83.2 | 88.2 | 75.0 | 16.0  | 16.0  | 1.0 | 27   | 23  | 27  | 24    |
| AA7     | 85.2 | 82.4 | 86.9 | 74.0 | 15.5  | 15.5  | 1.3 | 22   | 26  | 22  | 24    |
| AA8     | 86.8 | 83.5 | 88.4 | 74.6 | 16.5  | 16.0  | 1.4 | 22   | 24  | 23  | 26    |
| Avg     | 86.2 | 83.1 | 87.8 | 74.5 | 16.6  | 16.2  | 1.2 | 23   | 24  | 25  | 27    |
| STD DEV | 0.6  | 0.5  | 0.6  | 0.4  | 1.0   | 0.7   | 0.1 |      |     |     |       |
| 90% CI  | 0.5  | 0.4  | 0.5  | 0.4  | 0.8   | 0.6   | 0.1 |      |     |     |       |

LEVEL FLYOVER PILOT 2-2  
CENTERLINE CENTER

|         | EPNL | SEL  | PNLT <sub>a</sub> | ALM  | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|------|-------|-------|-----|------|-----|-----|-------|
| AY19    | 86.1 | 82.7 | 89.0              | 75.2 | 10.5  | 10.0  | 1.2 | 22   | 24  | 26  | 22    |
| AY20    | 87.1 | 83.7 | 89.8              | 75.7 | 14.5  | 13.5  | 1.4 | 23   | 23  | 26  | 27    |
| AY21    | 86.9 | 83.5 | 89.9              | 76.4 | 9.5   | 9.0   | 1.0 | 22   | 23  | 26  | 24    |
| AY22    | 86.5 | 83.2 | 88.6              | 74.7 | 14.0  | 13.0  | 1.3 | 23   | 23  | 26  | 27    |
| AY23    | 87.5 | 84.2 | 89.9              | 76.5 | 11.5  | 11.5  | 1.1 | 22   | 24  | 23  | 22    |
| AY24    | 88.0 | 84.7 | 90.4              | 77.4 | 14.0  | 14.5  | 1.2 | 23   | 23  | 26  | 27    |
| AY25    | 87.4 | 84.0 | 89.7              | 76.6 | 13.0  | 13.5  | 0.9 | 23   | 26  | 23  | 27    |
| AY27    | 87.6 | 83.7 | 90.3              | 76.5 | 13.0  | 13.5  | 1.2 | 23   | 23  | 26  | 34    |
| AY28    | 86.6 | 83.1 | 89.4              | 75.4 | 15.5  | 14.0  | 1.3 | 23   | 23  | 26  | 27    |
| AY29    | 87.0 | 83.5 | 89.5              | 76.0 | 13.5  | 12.5  | 0.9 | 22   | 23  | 26  | 24    |
| AY30    | 86.7 | 83.4 | 90.6              | 76.2 | 18.5  | 13.5  | 1.7 | 23   | 23  | 26  | 33    |
| Avg     | 87.0 | 83.6 | 89.7              | 76.1 | 13.4  | 12.6  | 1.2 | 23   | 24  | 26  | 27    |
| STD DEV | 0.6  | 0.6  | 0.6               | 0.7  | 2.4   | 1.7   | 0.2 |      |     |     |       |
| 90% CI  | 0.3  | 0.3  | 0.3               | 0.4  | 1.3   | 0.9   | 0.1 |      |     |     |       |

SIDELINE LEFT SITE 2 & 3

|         | EPNL | SEL  | PNLT <sub>a</sub> | ALM  | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|------|-------|-------|-----|------|-----|-----|-------|
| AY19    | 88.4 | 84.9 | 90.0              | 76.4 | 17.0  | 16.5  | 1.8 | 22   | 32  | 33  | 34    |
| AY20    | 88.3 | 84.6 | 89.4              | 75.2 | 18.0  | 17.5  | 1.5 | 20   | 23  | 33  | 32    |
| AY21    | 89.0 | 85.6 | 91.0              | 77.2 | 15.0  | 14.0  | 2.1 | 20   | 32  | 33  | 34    |
| AY22    | NA   | NA   | NA                | NA   | 21.5  | 20.0  | 1.7 | 20   | 23  | 33  | 32    |
| AY23    | 89.0 | 85.6 | 91.4              | 77.4 | 19.0  | 16.0  | 1.4 | 22   | 23  | 32  | 22    |
| AY24    | NA   | NA   | NA                | NA   | 17.5  | 16.0  | 1.6 | 22   | 23  | 22  | 32    |
| AY25    | 89.0 | 85.3 | 90.5              | 76.1 | 19.5  | 15.0  | 1.6 | 22   | 23  | 22  | 33    |
| AY27    | 89.0 | 85.5 | 91.0              | 76.8 | 20.0  | 17.0  | 1.4 | 22   | 23  | 33  | 34    |
| AY28    | 88.3 | 84.4 | 90.5              | 75.6 | 20.0  | 17.0  | 1.8 | 22   | 23  | 22  | 33    |
| AY29    | 88.0 | 84.2 | 89.9              | 75.6 | 16.0  | 15.5  | 1.6 | 22   | 23  | 22  | 33    |
| AY30    | 88.4 | 84.6 | 90.6              | 75.2 | 26.0  | 21.5  | 1.8 | 23   | 23  | 33  | 32    |
| Avg     | 88.6 | 85.0 | 90.5              | 76.2 | 19.1  | 16.9  | 1.7 | 22   | 25  | 29  | 32    |
| STD DEV | 0.4  | 0.6  | 0.6               | 0.8  | 0.3   | 2.2   | 0.2 |      |     |     |       |
| 90% CI  | 0.3  | 0.3  | 0.4               | 0.5  | 1.6   | 1.2   | 0.1 |      |     |     |       |

SIDELINE RIGHT SITE 2 & 3

|         | EPNL | SEL  | PNLT <sub>a</sub> | ALM  | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|------|-------|-------|-----|------|-----|-----|-------|
| AY19    | 88.8 | 84.8 | 91.3              | 76.9 | 16.0  | 15.0  | 1.6 | 22   | 24  | 34  | 35    |
| AY20    | 88.0 | 84.1 | 89.3              | 75.4 | 16.5  | 18.0  | 1.4 | 22   | 24  | 34  | 27    |
| AY21    | 87.7 | 84.1 | 89.8              | 76.0 | 14.5  | 14.5  | 1.6 | 22   | 24  | 34  | 27    |
| AY22    | NA   | NA   | NA                | NA   | 16.5  | 16.0  | 0.3 | 22   | 24  | 34  | 26    |
| AY23    | 87.6 | 84.2 | 88.9              | 76.1 | 19.0  | 19.0  | 1.3 | 22   | 26  | 33  | 24    |
| AY24    | NA   | NA   | NA                | NA   | 28.5  | 28.5  | 0.7 | 26   | 23  | 24  | 26    |
| AY25    | 87.6 | 84.1 | 88.7              | 75.6 | 15.5  | 15.5  | 0.9 | 22   | 23  | 24  | 22    |
| AY27    | NA   | 84.3 | 89.0              | 75.8 | 19.0  | NA    | 0.9 | 22   | 34  | 22  | 23    |
| AY28    | 85.8 | 82.8 | 87.3              | 74.6 | 18.0  | 20.0  | 1.1 | 22   | 26  | 22  | 24    |
| AY29    | 87.3 | 83.9 | 88.0              | 75.2 | 17.5  | 18.0  | 0.8 | 28   | 23  | 26  | 34    |
| AY30    | 85.7 | 82.7 | 86.6              | 73.9 | 21.5  | 22.0  | 1.7 | 27   | 27  | 25  | 34    |
| Avg     | 87.3 | 83.9 | 88.8              | 75.5 | 18.4  | 18.7  | 1.2 | 23   | 25  | 28  | 28    |
| STD DEV | 1.1  | 0.7  | 1.4               | 0.9  | 3.9   | 4.2   | 0.4 |      |     |     |       |
| 90% CI  | 0.7  | 0.4  | 0.9               | 0.5  | 2.1   | 2.4   | 0.2 |      |     |     |       |

# FLYOVER

## Three Mic Averages

### Pilot 1-1

|         | EPNL | SEL  | PNLT <sub>m</sub> | AL <sub>a</sub> |
|---------|------|------|-------------------|-----------------|
| A1      | 87.1 | 83.6 | 88.4              | 74.8            |
| A2      | 87.0 | 83.5 | 88.1              | 74.3            |
| A4      | 87.2 | 83.8 | 88.3              | 74.5            |
| A5      | 86.4 | 83.1 | 87.6              | 74.2            |
| A6      | 86.7 | 83.2 | 88.1              | 74.5            |
| A7      | 86.6 | 83.3 | 88.3              | 74.8            |
| A8      | 86.8 | 83.5 | 88.0              | 74.3            |
| Avg     | 86.8 | 83.4 | 88.1              | 74.5            |
| STD DEV | 0.3  | 0.2  | 0.3               | 0.3             |
| 90% CI  | 0.2  | 0.2  | 0.2               | 0.2             |

### Pilot 1-2

|         | EPNL | SEL  | PNLT <sub>m</sub> | AL <sub>a</sub> |
|---------|------|------|-------------------|-----------------|
| AZ27    | 87.4 | 83.9 | 89.4              | 75.8            |
| AZ28    | 87.4 | 84.0 | 89.2              | 75.8            |
| AZ29    | 87.1 | 83.6 | 89.4              | 75.4            |
| AZ30    | 87.1 | 83.6 | 89.1              | 75.5            |
| Avg     | 87.2 | 83.8 | 89.3              | 75.6            |
| STD DEV | 0.2  | 0.2  | 0.1               | 0.2             |
| 90% CI  | 0.2  | 0.3  | 0.2               | 0.2             |

### Pilot 2-1

|         | EPNL | SEL  | PNLT <sub>m</sub> | AL <sub>a</sub> |
|---------|------|------|-------------------|-----------------|
| AA2     | 87.1 | 83.9 | 88.8              | 75.2            |
| AA3     | 87.3 | 84.1 | 88.8              | 75.1            |
| AA5     | 86.6 | 83.5 | 88.7              | 74.8            |
| AA6     | 87.0 | 83.7 | 89.2              | 75.8            |
| AA7     | 86.0 | 83.4 | 88.7              | 75.0            |
| AA8     | 87.2 | 83.8 | 89.1              | 75.4            |
| Avg     | 87.0 | 83.7 | 88.9              | 75.2            |
| STD DEV | 0.3  | 0.3  | 0.2               | 0.4             |
| 90% CI  | 0.3  | 0.2  | 0.2               | 0.3             |

### Pilot 2-2

|         | EPNL | SEL  | PNLT <sub>m</sub> | AL <sub>a</sub> |
|---------|------|------|-------------------|-----------------|
| AY19    | 87.7 | 84.1 | 90.1              | 76.2            |
| AY20    | 87.8 | 84.1 | 89.5              | 75.4            |
| AY21    | 87.9 | 84.4 | 90.2              | 76.5            |
| AY22    | NA   | NA   | NA                | NA              |
| AY23    | 88.0 | 84.7 | 90.0              | 76.7            |
| AY24    | NA   | NA   | NA                | NA              |
| AY25    | 88.0 | 84.5 | 89.6              | 76.1            |
| AY27    | NA   | 84.5 | 90.1              | 76.0            |
| AY28    | 86.9 | 83.4 | 89.0              | 75.2            |
| AY29    | 87.4 | 83.9 | 89.1              | 75.6            |
| AY30    | 86.9 | 83.6 | 89.2              | 75.1            |
| Avg     | 87.6 | 84.1 | 89.7              | 75.9            |
| STD DEV | 0.5  | 0.4  | 0.5               | 0.6             |
| 90% CI  | 0.3  | 0.3  | 0.3               | 0.4             |

TAKEOFF PILOT 1-1  
CENTERLINE CENTER

|         | EPNL | SEL  | PNLT <sub>a</sub> | AL <sub>a</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| B33     | 86.5 | 83.0 | 87.9              | 73.5            | 17.0  | 15.5  | 2.1 | 22   | 22  | 25  | 35    |
| B37     | 86.1 | 82.2 | 87.6              | 72.6            | 19.5  | 15.5  | 1.9 | 22   | 22  | 25  | 34    |
| B39     | 86.8 | 82.5 | 88.3              | 73.9            | 19.5  | 16.5  | 1.7 | 22   | 25  | 35  | 34    |
| B41     | 86.3 | 82.6 | 87.9              | 73.6            | 18.0  | 16.5  | 2.1 | 22   | 22  | 25  | 35    |
| B43     | 87.4 | 83.4 | 88.1              | 73.3            | 25.5  | 19.0  | 2.2 | 22   | 22  | 25  | 24    |
| B45     | 87.0 | 83.3 | 88.5              | 74.1            | 23.0  | 16.5  | 2.2 | 22   | 22  | 25  | 34    |
| B47     | 87.3 | 82.9 | 89.9              | 74.0            | 19.5  | 14.0  | 2.4 | 22   | 22  | 25  | 35    |
| B49     | 86.7 | 82.8 | 88.4              | 73.1            | 17.5  | 15.0  | 2.1 | 22   | 22  | 25  | 34    |
| B52     | 86.2 | 82.4 | 88.0              | 73.5            | 17.5  | 15.5  | 2.2 | 22   | 22  | 25  | 34    |
| Avg     | 86.7 | 82.8 | 88.3              | 73.5            | 19.7  | 16.0  | 2.1 | 22   | 22  | 26  | 33    |
| STD DEV | 0.5  | 0.4  | 0.7               | 0.5             | 2.8   | 1.4   | 0.2 |      |     |     |       |
| 90% CI  | 0.3  | 0.3  | 0.4               | 0.3             | 1.8   | 0.9   | 0.1 |      |     |     |       |

SIDELINE LEFT

|         | EPNL | SEL  | PNLT <sub>a</sub> | AL <sub>a</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| B33     | 86.6 | 83.3 | 87.8              | 73.2            | 20.0  | 17.0  | 2.8 | 22   | 24  | 22  | 32    |
| B37     | 87.1 | 83.8 | 87.7              | 73.1            | 26.0  | 25.0  | 2.4 | 19   | 22  | 24  | 34    |
| B39     | 87.5 | 83.4 | 88.8              | 73.4            | 24.0  | 22.5  | 2.8 | 22   | 22  | 24  | 32    |
| B41     | 86.9 | 83.9 | 88.0              | 74.3            | 21.0  | 19.0  | 2.7 | 22   | 24  | 32  | 34    |
| B43     | 85.7 | 82.0 | 86.7              | 71.5            | 25.5  | 20.5  | 2.7 | 22   | 22  | 24  | 32    |
| B45     | 87.0 | 83.5 | 87.9              | 72.8            | 26.0  | 21.0  | 2.7 | 22   | 22  | 24  | 32    |
| B47     | 87.3 | 83.6 | 88.6              | 73.9            | 28.5  | 22.5  | 2.3 | 22   | 22  | 24  | 26    |
| B49     | 87.2 | 83.6 | 87.7              | 73.5            | 22.5  | 21.0  | 2.5 | 22   | 34  | 33  | 32    |
| B52     | 86.7 | 83.4 | 87.1              | 72.6            | 23.5  | 19.5  | 2.6 | 19   | 22  | 24  | 32    |
| Avg     | 86.9 | 83.4 | 87.8              | 73.1            | 24.1  | 20.9  | 2.6 | 21   | 24  | 26  | 32    |
| STD DEV | 0.5  | 0.6  | 0.7               | 0.8             | 2.7   | 2.3   | 0.2 |      |     |     |       |
| 90% CI  | 0.3  | 0.3  | 0.4               | 0.5             | 1.7   | 1.4   | 0.1 |      |     |     |       |

SIDELINE RIGHT

|         | EPNL | SEL  | PNLT <sub>a</sub> | AL <sub>a</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| B33     | 87.0 | 83.4 | 88.6              | 72.6            | 26.0  | 21.5  | 2.5 | 22   | 24  | 22  | 34    |
| B37     | NA   | NA   | NA                | NA              | 26.5  | 21.5  | 2.2 | 22   | 24  | 22  | 26    |
| B39     | 86.7 | 83.0 | 87.9              | 72.0            | 27.5  | 21.0  | 2.6 | 22   | 24  | 22  | 27    |
| B41     | 86.0 | 82.6 | 86.9              | 72.0            | 25.0  | 23.5  | 2.6 | 22   | 24  | 22  | 34    |
| B43     | 85.7 | 82.0 | 87.2              | 71.6            | 23.5  | 20.0  | 2.6 | 22   | 24  | 22  | 27    |
| B45     | 85.9 | 82.2 | 87.2              | 71.3            | 28.5  | 21.0  | 2.6 | 22   | 24  | 22  | 26    |
| B47     | 86.4 | 82.3 | 87.9              | 72.0            | 28.0  | 23.0  | 2.1 | 22   | 24  | 22  | 27    |
| B49     | 86.5 | 82.9 | 88.2              | 72.2            | 23.0  | 18.5  | 2.6 | 22   | 24  | 22  | 34    |
| B52     | 85.7 | 82.1 | 86.2              | 70.7            | 25.5  | 23.5  | 2.6 | 22   | 24  | 22  | 34    |
| Avg     | 86.2 | 82.6 | 87.5              | 71.8            | 25.9  | 21.5  | 2.5 | 22   | 24  | 22  | 30    |
| STD DEV | 0.5  | 0.5  | 0.8               | 0.6             | 1.9   | 1.7   | 0.2 |      |     |     |       |
| 90% CI  | 0.3  | 0.3  | 0.5               | 0.4             | 1.2   | 1.0   | 0.1 |      |     |     |       |

TAKEOFF PILOT 1-2  
CENTERLINE CENTER

|         | EPNL | SEL  | PNLT <sub>b</sub> | AL <sub>a</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| BZ32    | 86.2 | 82.8 | 87.6              | 73.5            | 24.0  | 17.5  | 2.2 | 22   | 22  | 24  | 32    |
| BZ34    | 86.3 | 82.9 | 87.2              | 73.5            | 24.5  | 19.5  | 2.0 | 22   | 22  | 35  | 34    |
| BZ36    | 86.7 | 83.3 | 87.9              | 73.3            | 26.5  | 19.5  | 2.1 | 22   | 22  | 24  | 26    |
| BZ38    | 86.3 | 82.9 | 88.0              | 72.4            | 34.0  | 17.0  | 2.2 | 22   | 22  | 25  | 35    |
| BZ40    | 86.5 | 82.4 | 88.0              | 72.8            | 19.5  | 17.0  | 2.0 | 22   | 22  | 35  | 34    |
| Avg     | 86.4 | 82.9 | 87.7              | 73.1            | 25.7  | 18.1  | 2.1 | 22   | 22  | 29  | 32    |
| STD DEV | 0.2  | 0.3  | 0.4               | 0.5             | 5.3   | 1.3   | 0.1 |      |     |     |       |
| 90% CI  | 0.2  | 0.3  | 0.3               | 0.5             | 5.1   | 1.2   | 0.1 |      |     |     |       |

SIDELINE LEFT

|         | EPNL | SEL  | PNLT <sub>b</sub> | AL <sub>a</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| BZ32    | 87.4 | 83.8 | 88.1              | 73.7            | 27.0  | 21.5  | 2.6 | 22   | 22  | 24  | 33    |
| BZ34    | 87.5 | 83.8 | 88.9              | 73.6            | 25.5  | 20.5  | 2.7 | 22   | 22  | 24  | 34    |
| BZ36    | 87.7 | 83.9 | 89.3              | 73.8            | 23.5  | 20.0  | 2.7 | 22   | 22  | 24  | 34    |
| BZ38    | 86.7 | 83.1 | 88.4              | 73.0            | 31.0  | 16.5  | 2.7 | 22   | 22  | 24  | 34    |
| BZ40    | 87.6 | 83.8 | 88.6              | 72.9            | 41.0  | 19.0  | 2.6 | 22   | 22  | 34  | 33    |
| Avg     | 87.4 | 83.7 | 88.7              | 73.4            | 29.6  | 19.5  | 2.7 | 22   | 22  | 26  | 34    |
| STD DEV | 0.4  | 0.3  | 0.5               | 0.4             | 6.9   | 1.9   | 0.0 |      |     |     |       |
| 90% CI  | 0.4  | 0.3  | 0.4               | 0.4             | 6.6   | 1.8   | 0.0 |      |     |     |       |

SIDELINE RIGHT

|         | EPNL | SEL  | PNLT <sub>b</sub> | AL <sub>a</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| BZ32    | 86.0 | 82.4 | 87.6              | 72.1            | 25.0  | 22.5  | 2.5 | 22   | 24  | 22  | 34    |
| BZ34    | 86.5 | 82.8 | 87.9              | 72.3            | 25.5  | 23.0  | 2.5 | 22   | 24  | 22  | 26    |
| BZ36    | 85.9 | 82.6 | 87.2              | 71.5            | 25.0  | 21.5  | 2.5 | 22   | 24  | 22  | 34    |
| BZ38    | 85.5 | 82.1 | 86.8              | 71.2            | 31.0  | 22.0  | 2.3 | 22   | 24  | 22  | 34    |
| BZ40    | 85.7 | 82.2 | 86.7              | 71.4            | 25.5  | 21.5  | 2.5 | 22   | 24  | 22  | 27    |
| Avg     | 85.9 | 82.4 | 87.2              | 71.7            | 26.4  | 22.1  | 2.5 | 22   | 24  | 22  | 31    |
| STD DEV | 0.4  | 0.3  | 0.5               | 0.5             | 2.6   | 0.7   | 0.1 |      |     |     |       |
| 90% CI  | 0.3  | 0.3  | 0.5               | 0.4             | 2.5   | 0.6   | 0.1 |      |     |     |       |

TAKEOFF PILOT 2-1  
CENTERLINE CENTER

|         | EPNL | SEL  | PNLT <sub>a</sub> | AL <sub>a</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| BB11    | 88.4 | 84.8 | 90.2              | 76.2            | 16.0  | 14.0  | 1.8 | 22   | 22  | 34  | 35    |
| BB13    | 88.8 | 85.1 | 89.2              | 75.3            | 19.5  | 18.0  | 1.9 | 22   | 22  | 35  | 34    |
| BB15    | 87.1 | 83.5 | 88.3              | 73.0            | 23.5  | 18.5  | 2.1 | 19   | 22  | 24  | 35    |
| BB17    | 87.0 | 83.7 | 88.3              | 73.9            | 22.5  | 20.0  | 1.9 | 19   | 22  | 35  | 34    |
| BB19    | 86.6 | 82.8 | 88.5              | 74.2            | 20.0  | 18.5  | 2.1 | 19   | 22  | 24  | 35    |
| BB23    | 88.5 | 85.1 | 90.3              | 75.1            | 21.5  | 18.5  | 2.4 | 19   | 22  | 24  | 34    |
| BB25    | 87.7 | 84.1 | 89.1              | 74.1            | 20.5  | 16.0  | 1.9 | 22   | 22  | 35  | 34    |
| Avg     | 87.7 | 84.1 | 89.1              | 74.5            | 20.5  | 17.6  | 2.0 | 20   | 22  | 30  | 34    |
| STD DEV | 0.9  | 0.8  | 0.8               | 1.1             | 2.4   | 2.0   | 0.2 |      |     |     |       |
| 90% CI  | 0.6  | 0.6  | 0.6               | 0.8             | 1.8   | 1.5   | 0.1 |      |     |     |       |

SIDELINE LEFT

|         | EPNL | SEL  | PNLT <sub>a</sub> | AL <sub>a</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| BB11    | 87.8 | 84.0 | 88.2              | 73.5            | 26.5  | 22.5  | 2.6 | 22   | 24  | 22  | 33    |
| BB13    | 88.3 | 84.4 | 89.6              | 74.5            | 24.5  | 21.5  | 2.8 | 22   | 22  | 24  | 33    |
| BB15    | 86.7 | 82.9 | 88.8              | 73.2            | 26.0  | 18.0  | 2.7 | 22   | 22  | 24  | 34    |
| BB17    | 86.4 | 82.4 | 87.2              | 72.0            | 25.0  | 23.5  | 2.7 | 22   | 22  | 24  | 34    |
| BB19    | 86.4 | 82.4 | 88.9              | 73.2            | 25.0  | 20.0  | 2.7 | 22   | 22  | 24  | 34    |
| BB23    | 87.6 | 83.5 | 89.3              | 73.6            | 25.5  | 21.0  | 2.8 | 22   | 22  | 24  | 33    |
| BB25    | 87.8 | 84.0 | 88.8              | 73.7            | 29.0  | 21.5  | 2.8 | 22   | 22  | 24  | 27    |
| Avg     | 87.3 | 83.4 | 88.7              | 73.4            | 25.9  | 21.1  | 2.7 | 22   | 22  | 24  | 33    |
| STD DEV | 0.8  | 0.8  | 0.8               | 0.8             | 1.5   | 1.8   | 0.1 |      |     |     |       |
| 90% CI  | 0.6  | 0.6  | 0.6               | 0.6             | 1.1   | 1.3   | 0.1 |      |     |     |       |

SIDELINE RIGHT

|         | EPNL | SEL  | PNLT <sub>a</sub> | AL <sub>a</sub> | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|-----------------|-------|-------|-----|------|-----|-----|-------|
| BB11    | 86.6 | 82.9 | 88.2              | 73.0            | 22.5  | 20.0  | 2.5 | 22   | 24  | 22  | 27    |
| BB13    | 86.4 | 82.8 | 89.0              | 73.2            | 24.5  | 17.5  | 2.6 | 22   | 24  | 22  | 34    |
| BB15    | 87.0 | 83.3 | 87.8              | 72.9            | 24.0  | 22.5  | 2.5 | 22   | 24  | 22  | 26    |
| BB17    | 86.4 | 82.5 | 87.8              | 71.9            | 26.0  | 23.0  | 2.6 | 22   | 24  | 22  | 27    |
| BB19    | 85.7 | 81.8 | 88.5              | 72.8            | 28.0  | 25.5  | 2.6 | 22   | 24  | 22  | 26    |
| BB23    | 86.5 | 82.9 | 86.9              | 72.2            | 29.5  | 25.0  | 2.6 | 22   | 22  | 24  | 34    |
| BB25    | 87.0 | 83.3 | 88.8              | 73.2            | 27.5  | 19.5  | 2.6 | 22   | 24  | 22  | 26    |
| Avg     | 86.5 | 82.8 | 88.2              | 72.7            | 26.0  | 21.9  | 2.6 | 22   | 24  | 22  | 29    |
| STD DEV | 0.5  | 0.5  | 0.7               | 0.5             | 2.5   | 3.0   | 0.1 |      |     |     |       |
| 90% CI  | 0.3  | 0.4  | 0.5               | 0.4             | 1.8   | 2.2   | 0.0 |      |     |     |       |

TAKEOFF PILOT 2-2  
CENTERLINE CENTER

|         | EPNL | SEL  | PNLT <sub>m</sub> | ALB  | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|------|-------|-------|-----|------|-----|-----|-------|
| BY3     | 88.4 | 85.2 | 89.0              | 75.4 | 20.5  | 17.0  | 1.4 | 22   | 35  | 34  | 22    |
| BY5     | 89.1 | 85.3 | 90.2              | 75.9 | 21.0  | 18.5  | 1.7 | 22   | 35  | 34  | 33    |
| BY9     | 89.3 | 85.5 | 91.5              | 76.3 | 19.0  | 13.0  | 2.2 | 22   | 22  | 25  | 35    |
| BY11    | 88.4 | 84.9 | 90.5              | 76.0 | 17.0  | 14.0  | 2.2 | 22   | 22  | 35  | 34    |
| BY13    | 88.3 | 84.6 | 89.5              | 75.1 | 19.0  | 15.5  | 2.1 | 22   | 22  | 35  | 34    |
| BY15    | 92.4 | 88.4 | 94.6              | 79.5 | 19.0  | 18.0  | 2.2 | 19   | 22  | 35  | 24    |
| BY17    | 89.9 | 86.4 | 89.7              | 75.4 | 23.0  | 21.5  | 1.9 | 22   | 22  | 35  | 34    |
| Avg     | 89.4 | 85.8 | 90.7              | 76.2 | 19.8  | 16.8  | 2.0 | 22   | 26  | 33  | 31    |
| STD DEV | 1.4  | 1.3  | 1.9               | 1.5  | 1.9   | 2.9   | 0.3 |      |     |     |       |
| 90% CI  | 1.1  | 0.9  | 1.4               | 1.1  | 1.4   | 2.1   | 0.2 |      |     |     |       |

SIDELINE LEFT

|         | EPNL | SEL  | PNLT <sub>m</sub> | ALB  | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|------|-------|-------|-----|------|-----|-----|-------|
| BY3     | 88.4 | 84.5 | 89.9              | 74.5 | 22.5  | 19.5  | 2.6 | 22   | 22  | 24  | 34    |
| BY5     | 88.5 | 84.3 | 89.8              | 73.8 | 28.0  | 21.5  | 2.7 | 22   | 22  | 24  | 34    |
| BY9     | 90.1 | 85.7 | 90.6              | 75.5 | 24.0  | 23.0  | 2.7 | 22   | 22  | 24  | 34    |
| BY11    | NA   | NA   | NA                | NA   | 23.0  | 22.0  | 2.7 | 22   | 22  | 24  | 34    |
| BY13    | 88.3 | 84.4 | 89.4              | 74.3 | 26.5  | 19.5  | 2.6 | 22   | 22  | 24  | 34    |
| BY15    | 89.6 | 85.3 | 90.6              | 75.2 | 24.0  | 17.0  | 2.6 | 22   | 22  | 34  | 33    |
| BY17    | 88.8 | 84.7 | 90.7              | 75.4 | 20.0  | 15.0  | 2.7 | 22   | 22  | 24  | 33    |
| Avg     | 89.0 | 84.8 | 90.2              | 74.8 | 24.0  | 19.6  | 2.7 | 22   | 22  | 24  | 34    |
| STD DEV | 0.7  | 0.6  | 0.5               | 0.7  | 2.6   | 2.9   | 0.1 |      |     |     |       |
| 90% CI  | 0.6  | 0.5  | 0.4               | 0.6  | 1.9   | 2.1   | 0.0 |      |     |     |       |

SIDELINE RIGHT

|         | EPNL | SEL  | PNLT <sub>m</sub> | ALB  | DUR A | DUR P | TC  | BAND | MAX | NOY | BANDS |
|---------|------|------|-------------------|------|-------|-------|-----|------|-----|-----|-------|
| BY3     | 87.8 | 83.7 | 89.4              | 73.8 | 22.0  | 20.5  | 2.2 | 22   | 24  | 22  | 34    |
| BY5     | 87.2 | 83.3 | 89.5              | 73.6 | 26.0  | 20.5  | 2.5 | 22   | 24  | 22  | 35    |
| BY9     | 87.3 | 83.5 | 90.4              | 74.8 | 19.5  | 14.0  | 2.5 | 22   | 24  | 22  | 34    |
| BY11    | 87.0 | 83.1 | 89.4              | 73.7 | 23.0  | 18.0  | 2.4 | 22   | 24  | 22  | 34    |
| BY13    | 87.5 | 83.6 | 88.1              | 72.6 | 24.0  | 20.5  | 2.5 | 22   | 24  | 22  | 27    |
| BY15    | 87.2 | 83.6 | 88.7              | 73.2 | 23.0  | 17.5  | 2.4 | 22   | 24  | 22  | 34    |
| BY17    | 87.5 | 83.7 | 89.3              | 73.7 | 25.0  | 20.0  | 2.4 | 22   | 24  | 22  | 27    |
| Avg     | 87.3 | 83.5 | 89.3              | 73.7 | 23.2  | 18.7  | 2.4 | 22   | 24  | 22  | 32    |
| STD DEV | 0.3  | 0.2  | 0.7               | 0.7  | 2.1   | 2.4   | 0.1 |      |     |     |       |
| 90% CI  | 0.2  | 0.2  | 0.5               | 0.5  | 1.6   | 1.8   | 0.1 |      |     |     |       |

# TAKE-OFF

## Three Mic Averages

### Pilot 1-1

|         | EPNL | SEL  | PNLT <sub>a</sub> | AL <sub>d</sub> |
|---------|------|------|-------------------|-----------------|
| B33     | 86.7 | 83.2 | 88.1              | 73.1            |
| B37     | NA   | NA   | NA                | NA              |
| B39     | 87.0 | 83.0 | 88.3              | 73.1            |
| B41     | 86.4 | 83.0 | 87.6              | 73.3            |
| B43     | 86.3 | 82.5 | 87.3              | 72.1            |
| B45     | 86.6 | 83.0 | 87.9              | 72.7            |
| B47     | 87.0 | 82.9 | 88.8              | 73.3            |
| B49     | 86.8 | 83.1 | 88.1              | 72.9            |
| B52     | 86.2 | 82.6 | 87.1              | 72.3            |
| AVG     | 86.6 | 82.9 | 87.9              | 72.9            |
| STD DEV | 0.3  | 0.3  | 0.6               | 0.5             |
| 90% CI  | 0.2  | 0.2  | 0.4               | 0.3             |

### Pilot 1-2

|         | EPNL | SEL  | PNLT <sub>a</sub> | AL <sub>d</sub> |
|---------|------|------|-------------------|-----------------|
| B232    | 86.5 | 83.0 | 87.8              | 73.1            |
| B234    | 86.8 | 83.2 | 88.0              | 73.1            |
| B236    | 86.8 | 83.3 | 88.1              | 72.9            |
| B238    | 86.2 | 82.7 | 87.7              | 72.2            |
| B240    | 86.6 | 82.8 | 87.8              | 72.4            |
| AVG     | 86.6 | 83.0 | 87.9              | 72.7            |
| STD DEV | 0.3  | 0.3  | 0.2               | 0.2             |
| 90% CI  | 0.2  | 0.2  | 0.2               | 0.4             |

### Pilot 2-1

|         | EPNL | SEL  | PNLT <sub>a</sub> | AL <sub>d</sub> |
|---------|------|------|-------------------|-----------------|
| BB11    | 87.6 | 83.9 | 88.9              | 74.2            |
| BB13    | 87.8 | 84.1 | 89.3              | 74.3            |
| BB15    | 86.9 | 83.2 | 88.3              | 73.0            |
| BB17    | 86.6 | 82.9 | 87.8              | 72.6            |
| BB19    | 86.2 | 82.3 | 88.6              | 73.4            |
| BB23    | 87.5 | 82.8 | 88.8              | 73.6            |
| BB25    | 87.5 | 83.8 | 88.9              | 73.7            |
| AVG     | 87.2 | 83.4 | 88.7              | 73.6            |
| STD DEV | 0.6  | 0.7  | 0.5               | 0.6             |
| 90% CI  | 0.4  | 0.5  | 0.4               | 0.5             |

### Pilot 2-2

|         | EPNL | SEL  | PNLT <sub>a</sub> | AL <sub>d</sub> |
|---------|------|------|-------------------|-----------------|
| BY3     | 88.2 | 84.5 | 89.4              | 74.6            |
| BY5     | 88.3 | 84.3 | 89.8              | 74.4            |
| BY9     | 88.9 | 84.9 | 90.8              | 75.5            |
| BY11    | NA   | NA   | NA                | NA              |
| BY13    | 88.0 | 84.2 | 89.0              | 74.0            |
| BY15    | 89.7 | 85.8 | 91.3              | 76.0            |
| BY17    | 88.7 | 84.9 | 89.9              | 74.8            |
| AVG     | 88.6 | 84.8 | 90.1              | 74.9            |
| STD DEV | 0.6  | 0.6  | 0.9               | 0.7             |
| 90% CI  | 0.5  | 0.5  | 0.7               | 0.6             |

END

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MARCH, 1988

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